Chapter 4

Chapter 4

4. AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

Chapter 4

4.1 CHAPTER INTRODUCTION

This chapter provides information describing the affected environment of western Washington forested state trust lands managed by the Washington Department of Natural Resources (DNR), including the policies, procedures, and strategies that govern their management. The affected environment sections describe the current condition of the forested trust lands against which the proposed Alternatives are evaluated. The following resource areas are discussed:

- Forest Structure and Vegetation (Section 4.2)
- Riparian Areas (Section 4.3)
- Wildlife (Section 4.4)
- Air Quality (Section 4.5)
- Geomorphology, Soils, and Sediment (Section 4.6)
- Hydrology (Section 4.7)
- Water Quality (Section 4.8)
- Wetlands (Section 4.9)
- Fish (Section 4.10)
- Public Utilities and Services (Section 4.11)
- Cultural Resources (Section 4.12)
- Recreation (Section 4.13)
- Scenic Resources (Section 4.14)
- Cumulative Effects (Section 4.15)

The environmental effects related to each of the above resource areas are discussed following a presentation of the affected environment. The environmental effects sections provide the scientific and analytical basis for the comparison of Alternatives presented in Chapter 2. Because of the long length of Section 4.2, Forest Structure and Vegetation, this section is presented in a somewhat different format than the others. General background material is presented first, then the affected environment and the associated environmental effects are presented separately for each of six major subsections.

The following Environmental Impact Statements are incorporated by reference in full: 1) the draft and final Forest Resource Plan Environmental Impact Statement (DNR 1992), (2) the draft and final Habitat Conservation Plan Environmental Impact Statement (DNR 1996); and 3) the draft and final Forest Practices Rules Environmental Impact Statement (Washington Forest Practices Board 2001). These EISs contain relevant information concerning the impacts of harvesting on forested trust lands managed by DNR, done in compliance with DNR's Habitat Conservation Plan, existing Forest Resource Plan policies, and the Forest Practices Rules that apply to both state and private lands. These EISs may be located in public libraries throughout the state of Washington, including the Washington State Library, depository libraries, university and college libraries, and county and city libraries. Many resource area sections in this EIS refer to information presented in the affected environment sections of those EISs. However, some information has been updated, and other subject areas (e.g., soil productivity, recreation) not covered in those EISs have been added.

The Forest Resource Plan and the Habitat Conservation Plan Environmental Impact Statements provide useful benchmarks for evaluating the effects of the 2003 sustainable harvest calculation level.

This is a programmatic Environmental Impact Statement (i.e., non-project under the State Environmental Policy Act). Consequently, the analysis for each resource area focuses specifically on evaluating the impacts of the policies and procedures that are being proposed for modification under the Alternatives. Conclusions are based on reasonably available data and generally qualitative analyses, supported by quantitative data where available and appropriate.

For some resource areas, changes in policy, procedure, or operational management proposed under the Alternatives are different for the Olympic Experimental State Forest compared to the other five Westside HCP Planning Units. Consequently, the likelihood of adverse effects may also be different. In these instances, the Olympic Experimental State Forest is discussed separately from the other five Westside HCP Planning Units.

The temporal scale for resource analyses is both the short term (10 years) and long term (30 to 64 years). These time periods reflect the planning period for the sustainable harvest calculation and the remaining lifespan, to 2067, of the 70-year Habitat Conservation Plan. Data are presented by decade for many resources.

The analyses presented in this chapter indicate that there are different levels of relative risk associated with the various Alternatives. Where this is the case, the Alternatives are ranked. Ranking does not imply that the Alternative with the highest risk rating would result in a significant adverse impact. In many cases, the higher ranking simply implies that greater care would be taken in implementing a strategy and higher levels of investment would likely be needed to ensure that careful planning, implementation, and monitoring are included at the project level.

4.2 FOREST STRUCTURE AND VEGETATION

4.2.1 Forest Structure

This section analyzes the environmental effects on forest structure, old forests, forest health, carbon sequestration, and threatened and endangered plant species. The analysis examines the current and proposed changes to policy and procedures under the different Alternatives. This analysis also assesses relative risks among Alternatives that are illustrated using modeling outputs.

Alternatives 1 and 4 would provide more old forest and would entail less risk of adversely affecting threatened, endangered, and sensitive plant species than the other Alternatives. However, Alternatives 1 and 4 would result in more dense forest stands that achieve lower individual tree growth rates and are more susceptible to damage from insects and disease. Alternative 2 and the Preferred Alternative are ranked intermediate in terms of their overall relative risk of causing negative environmental impacts. The Preferred Alternative has a higher risk associated with it over the short term, but in the long term ranks highest in the development of structurally complex forest stands. Both the Preferred Alternative and Alternative 2 would require an intermediate level of investment for successfully implementing their management strategies and achieving the projected level of harvest.

Alternatives 3 and 5 would have fewer policy limitations for stand management and timber harvest and would apply more intensive management strategies than the other Alternatives. Management proposed under Alternatives 3 and 5 would result in more harvest area and forests that are less susceptible to insect and disease damage.

Alternative 5 and the Preferred Alternative would entail more relative risk of adversely affecting threatened, endangered, and sensitive species of plants due to more harvest and harvest-related disturbance.

4.2.2 Introduction

This section describes the existing forest structure and vegetation resources on western Washington forested state trust lands, and assesses potential effects to these resources resulting from changes to DNR's management policies under the analyzed Alternatives. During the public scoping process, concerns were raised about the effects of the proposed Alternatives on forest conditions, growth and yield, forest health (including fire, insect, and disease damage, windthrow, and the spread of noxious weeds), and old forests. The following areas were assessed for effects of the proposed policy changes to the management of forest resources on forested trust lands:

- Forest Condition – Changes in the proportion of forest acreage within different forest stand development stages; changes in the quantity and types of forest management activities
- Growth and Yield – Potential factors changing individual tree and stand growth as indicated by changes in forest conditions (stand development stages and forest stand density)

- Forest Health – Changes to relative forest stand density as an indicator of stand vigor and fire risk as it relates to harvest intensity
- Old Forest – Acres of forest with old forest stand structure characteristics
- Carbon Sequestration – Changes in carbon storage capacity
- Threatened, Endangered, and Sensitive Plants – Frequency of potentially physically disturbing events, and management strategies and changes in stand complexity and understory development

Analysis of effects to the forest vegetation resources focuses on the approximately 1.4 million acres of western Washington forested state trust lands. Each of the six proposed Alternatives represents a strategy for implementing DNR's 70-year Habitat Conservation Plan (DNR 1997). The analysis covers the period between 2004 and 2067, and is to be re-assessed at periodic time intervals within this period.

4.2.3 Current Conditions

4.2.3.1 Physical Setting

The western Washington forested state trust lands span vegetation zones from near sea level to mountaintops. Vegetation zones represent areas of similar environmental settings (soils, climate, elevation, aspect, and disturbance regimes). Vegetation zones tend to occur sequentially up mountain slopes, depending upon changed conditions at these elevations—generally, changes in moisture and temperature levels (Franklin and Dyrness 1988). Vegetation zones are named for climax tree species that would dominate the area in the absence of wildfire, timber harvest, or windstorms, or until such a disturbance occurs. However, plant communities associated with a specific seral stage may occupy the site at any given time, depending on the forest's development.

The **western hemlock zone** covers approximately 71 percent of the forested trust lands. It extends from sea level to about 2,000 feet in elevation. Tree species include western hemlock, Douglas-fir, western red cedar, Pacific silver fir, grand fir, red alder, and bigleaf maple. Portions of the Puget Sound lowlands (see Chapter 3) located in the Olympic Mountains' rain shadow have gravelly glacial soils and relatively low rainfall. These areas often support lodgepole pine along with Douglas-fir.

The **Sitka spruce zone** is found in a narrow band along the Pacific Coast and in "fingers" up coastal river valleys where the climate is mild and moist year-round. Ten percent of the western Washington forested state trust lands is in the Sitka spruce zone. Mixed conifer forests, consisting of Sitka spruce, western hemlock, western red cedar, Douglas-fir, grand fir, Pacific silver fir, lodgepole pine, and red alder occur in this zone, though in different proportions than in the western hemlock zone.

The **Pacific silver fir zone** occupies approximately 16 percent of the forested trust lands. This zone generally occurs between 2,000 and 4,000 feet in elevation where the cool, wet climate results in a relatively short growing season. Pacific silver fir, noble fir (south of Stevens Pass), Douglas-fir, yellow cedar, western red cedar, and Sitka spruce are tree species that characterize this zone.

Less than 2 percent of the forested trust lands are in the high-elevation forest zones, which extend from about 4,000 feet in elevation up to the "tree line."

4.2.3.2 Forest Conditions

Disturbance has long been a factor in Pacific Northwest forests. The extensive Douglas-fir forests seen by European settlers in the nineteenth century were born of fire (Agee 1993; Franklin and Dyrness 1988). Wind was a major disturbance factor, especially in coastal Sitka spruce and higher elevation Pacific silver fir and alpine forests, where the moist conditions generally limited fire spread (Agee 1993). In higher elevations, snow-downed trees opened up the forest for regeneration. Insects and disease were also disturbance agents. Disturbance after European settlement has been primarily through timber harvest, land-clearing, and fire. Most of the western Washington forested state trust lands have been logged at least once in the past 100 years (DNR 1997).

Conditions that followed clearcutting (i.e., the removal of all trees) differ greatly from the conditions following most natural disturbances in terms of the structural legacies remaining after natural types of disturbance. Currently, DNR retains legacy trees (sometimes called reserve trees) in all harvests. Conversely, past clearcutting did not leave a legacy of overstory trees.

Clearcutting, as popularly conceived, removed all trees—merchantable as well as snags, cull trees, seedlings, saplings, tops, and branches—in order to start a new rotation with even-aged trees that would fully occupy the site. Following the timber harvest, large woody debris was lost with intensive slash disposal practices such as broadcast burning or piling and burning. With the exception of stands regenerated within the past 15 to 20 years and those destroyed by fire, most of the forest stands found on western Washington forested state trust lands were regenerated from past clearcutting.

4.2.3.3 Current Forest Management and Harvest Levels

Since 1996, and the adoption of the Habitat Conservation Plan, all regeneration harvests on western Washington forested state trust lands have followed the policy and procedural direction describe in Chapter 2 for Alternative 1 (No Action).

Table 4.2-1 shows the average annual acres of forest stand management activities that occurred on western Washington forested state trust lands from 1997 through 2002.

Table 4.2-2 displays the acres of pre-commercial thinning (thinning done before the trees are merchantable) that have occurred since DNR began implementation of the Habitat Conservation Plan.

Table 4.2-1. Average Annual Acres of Forest Management Activities by Habitat Conservation Plan Planning Unit, 1997 through 2002

		Site Preparation					Vegetation Management	
	Fertilization	Aerial Herbicide Application	Ground Herbicide Application	Mechanical	Pile and Burn	Broadcast Burn	Aerial Herbicide Application	Ground Herbicide Application
HCP Planning Unit	**Acres per Year**	**Acres per Year**	**Acres per Year**	**Acres per Year**	**Acres per Year**	**Acres per Year**	**Acres per Year**	**Acres per Year**
Straits	0	0	15	1	9	0	0	343
North Puget	1,114	338	0	0	6	10	704	1,533
South Puget	113	0	0	0	10	0	31	253
Columbia	0	573	123	40	80	5	1,473	260
South Coast	0	23	13	11	144	0	603	574
Olympic Experimental State Forest	0	0	0	0	20	0	0	60
Total	**1,227**	**934**	**151**	**52**	**269**	**15**	**2,811**	**3,023**

Data Source: DNR Planning and Tracking database.
Note: Area fertilized includes both application of biosolids and aerial fertilizer application in North Puget and South Puget HCP Planning Units. Area fertilized updated from e-mail communication from Carol Thayer, 7/24/03.

Table 4.2-2. Acres Pre-Commercially Thinned on Forested Trust Lands by Habitat Conservation Plan Planning Unit, 1996 through 2002

HCP Planning Unit	Average Acres/Year Pre-Commercially Thinned	Total Acres Pre-Commercially Thinned
Straits	624	3,743
North Puget	3,782	22,691
South Puget	830	4,982
Columbia	751	4,504
South Coast	1,604	9,621
Olympic Experimental State Forest	5,034	30,203
Total	**12,625**	**75,744**

Data Source: DNR Planning and Tracking database.

DNR is required to provide for long-term stable harvest of timber measured in volume according to Policy Nos. 4 and 5 (DNR 1992b). State law mandates the periodic recalculation of this sustained yield harvest (Revised Code of Washington 79.10.320). In 1996, the Board of Natural Resources adopted an annual sustainable harvest level of 655 million board feet for the forested trust lands statewide. This equates to approximately 575 million board feet as the sustainable harvest level for western Washington forested state trust lands.

During the past 5 years (1998 to 2002), an average of approximately 479 million board feet of timber per year (see Section 4.11, Table 4-11) has been harvested from approximately 20,000 acres of forested trust lands. The majority of the harvest volume removed was in the Central (Grays Harbor, Lewis, Pacific, and Thurston Counties) and Northwest Regions (Skagit, Snohomish, and Whatcom Counties). Each of these two regions produced about 31 and 27 percent, respectively, of the total 5-year timber volume yield. The Southwest Region (Clark, Cowlitz, Klickitat, Pacific, Skamania, and Wahkiakum Counties) contributed about 18 percent of the volume. The South Puget Sound (King, Kitsap, Lewis, Mason, and Pierce Counties) and Olympic (Clallam, Grays Harbor, and Jefferson Counties) Regions produced 13 and 12 percent of the total yield, respectively.

Table 4.2-3 displays the total current estimate for standing inventory by land class. The standing volume is expressed in both cubic feet and Scribner board feet to reflect the estimate of both total tree biomass in the forest (cubic feet) and an estimate of the merchantable standing volume (Scribner board feet) (see Chapter 2, Uncertainty in the Modeling Results, for further discussion). Approximately 26 percent of forested trust lands timber volume is located in the "Uplands with General Objectives" land class, 43 percent and 31 percent of the volume are in the "Uplands with Specific Objectives" and "Riparian" land classes, respectively. (See description of land classes in Chapter 6 Glossary)

The estimates of standing merchantable volume (Scribner board feet) differ from those published in the Draft Environmental Impact Statement (Draft EIS). In the Draft EIS, the standing volume was published as 52 billion board feet. This inventory figure was not adjusted for merchantability. (See Appendix B for details on growth and yield.)

4.2.4 Forest Structure, Growth, and Yield

4.2.4.1 Affected Environment

Forest Structure

The condition of a forest can be expressed in a number of ways. A popular way to measure the condition of even-aged forests in the Pacific Northwest is age class. For an even-aged

Table 4.2-3. Total Current Standing Timber Volume for Western Washington Forested State Trust Lands by Land Class

	Standing Volume	
Land Classification	**Billion Cubic Feet**	**Billion Board Feet (Scribner)**
Uplands with General Objectives	2	8
Uplands with Specific Objectives	3	13
Riparian	2	10
Total	**7**	**31**

Data Source: Model output data (stand development stages).

managed forest, an age class distribution can help describe the previous disturbance history. The extent of younger forests suggests that disturbances, regeneration harvests, and/or natural disturbances, have occurred recently. An older age class forest suggests that there have been less disturbance events in recent history. However, as a comparison of Photographs 1 and 2 in Chapter 2 illustrates, the use of stand age can be difficult to estimate and can be a deceiving measure for describing the condition of a forest stand. While age class is useful for describing the conditions of an even-aged forest managed for timber production, it is not considered as useful for describing the ecological conditions of a forest when managed for habitat conditions, which are typically represented in un-even-aged forests.

Ecological condition is best described with stand development stages that use structural conditions to define a developmental stage. Structural conditions include the number and size of live trees, standing dead trees (snags), and down woody debris. Describing a forest in terms of its structural conditions allows for an improved description of a forest's ecological condition because forest stand structure is related to ecological functioning. The stages used in this analysis are adapted from three principal sources: Brown (1985), Carey et al. (1996), and Johnson and O'Neil (2001).

The forest stand development stages used in this analysis differ from the "age class-based structural description" used to describe forest structure for the Habitat Conservation Plan. At the time that the Habitat Conservation Plan was developed, age class was the best available data. However, age class is not a sufficient indicator of stand structure, nor is it a satisfactory indicator of ecological functioning. This fact was recognized in the Habitat Conservation Plan, and methods were put in place to change management focus from age to structure (DNR 1997, page IV-180).

Many factors affect the rate at which a stand develops, including site conditions, tree genetics, the tree species used to initiate regeneration after harvest, the density of the new trees, natural disturbance, and management activities (Oliver and Larson 1996; Franklin et al. 2002).

The stand development stages used in this analysis are based on:

- number of tree canopy levels,
- tree size,
- percent of canopy closure (relative density),
- abundance of dead or decadent trees, and
- abundance of dead down wood.

Descriptions of these stand development stages are provided in Appendix B, Section B.2.3. The following is a brief description of how these stages develop. Ecosystem initiation stages are open, newly regenerated stands that are actively growing. Stands enter the competitive exclusion stages when competition for direct sunlight, nutrients, water, and space increases (Oliver and Larson 1996) and stands near, or exceed, full site occupancy. When growing space is fully occupied, stand growth measured in volume per unit area is probably at its peak. Stand growth only declines by mortality. As growing space becomes fully occupied, tree mortality ensues and the net stand growth begins declining. The understory development stage develops as stand gaps increase due to mortality of larger trees or groups of trees or silvicultural treatments. It is tree mortality that primarily influences forest development, not tree growth. In understory development, a stand has lost some of its large trees from the upper canopy due to mortality or a harvest, competition between trees is reduced, and understory trees and shrubs are developing. This stage is transitional; the stand may return to a competitive exclusion stage as the taller trees' crowns re-close, or conversely, the crowns may not close and the stand may develop into a botanically diverse or niche diversification stage. This later development occurs as a result of continued understory development and tree mortality. Botanically diverse, niche diversification, and fully functional development stages provide progressively more stand biodiversity and structural diversity with each development stage. In a botanically diverse stage, forest stands have two or more tree canopies but are lacking in dead tree components such as large snags and/or down woody debris. These components are all present in niche diversification and fully functional development stages. The distinction between niche diversification and fully functional is principally time to accumulate greater levels of structural and biological diversity.

Distribution of Stages

Table 4.2-4 displays the percent distribution of stand development stages on western Washington forested state trust lands, while Table 4.2-5 provides a breakdown by HCP Planning Unit. The ecosystem initiation stage comprises about 8 percent of forested trust

Table 4.2-4. Distribution of Stand Development Stages on Forested Trust Lands

Summarized Stand Development Stage	Stand Development Stage	Acres	Percent of Forested Trust Lands
Ecosystem Initiation	Ecosystem Initiation	105,240	8
Competitive Exclusion	Sapling Exclusion	234,979	17
	Pole Exclusion	286,880	21
	Large Tree Exclusion	226,347	16
	Understory Development	196,417	14
Structurally Complex	Botanical Diversity	324,725	23
	Niche Diversification	3,681	0
	Fully Functional	12,435	1
Total		**1,390,704**	**100**

Data source: Model output data - stand development stages.

Table 4.2-5. Stand Development Stages in Forested Trust Lands, by Habitat Conservation Plan Planning Unit

	HCP Planning Unit							
	Straits	North Puget	South Puget	Columbia	South Coast	OESF[1/]		
Forest Stand Development Stage	Percent of Total Acres	Percent of Total Acres	Percent of Total Acres	Percent of Total Acres	Percent of Total Acres	Percent of Total Acres	Total Percent of Forested Trust Lands	Total Acres
Ecosystem Initiation	7	8	7	7	8	8	8	**105,240**
Sapling Exclusion	11	17	25	15	17	15	17	**234,979**
Pole Exclusion	23	17	29	15	22	19	21	**286,880**
Large Tree Exclusion	26	13	6	27	13	11	16	**226,347**
Understory Development	11	17	6	18	15	21	14	**196,416**
Botanical Diversity	21	26	25	18	25	25	23	**324,724**
Niche Diversification	<1	0	1	<1	<1	<1	0	**3,683**
Fully Functional	1	2	1	<1	<1	<1	1	**12,435**
Total Percent	**100**	**100**	**100**	**100**	**100**	**100**	**100**	
Total Acres HCP Planning Unit	**110,222**	**381,516**	**141,845**	**267,530**	**232,931**	**256,659**		**1,390,704**

Data Source: Model output data – stand development stages.
[1/] OESF = Olympic Experimental State Forest
Note: Due to rounding, the numbers may not equal 100 percent when added.

lands. The competitive exclusion stage is the majority, about 69 percent (945,000 acres). In the table, the competitive exclusion stage includes the sapling exclusion, pole exclusion, large tree exclusion, and the understory development stages. Approximately 14 percent (196,000 acres) of the forest is estimated to be in an understory development stage. Approximately 25 percent (340,000 acres) of the forests are in botanically diverse, niche diversification, and fully functional development stages.

Forest Growth and Yield

"Forest growth and yield" refers to the change in surviving tree volume over time, i.e., individual tree and stand growth over time (yield). Characteristics that influence growth and yield are the species, spacing of trees in stands (density), and the site productivity of stands. The effects of the analyzed Alternatives are measured by how management activities change standing volumes and the distribution of stand development stage. Comparing the changes in standing inventory volumes and the changing distribution of stand development stages among Alternatives provides a means for summarizing the effects of changes in forest condition on future growth and yield of the forest base.

4.2.4.2 Environmental Effects

The Alternatives contain a number of changes to current policies and procedures. Table 4.2-6 summarizes the proposed changes to specific policies and procedures. Chapter 2 details proposed changes by Alternative, while Appendix C provides the current policies and procedures and the proposed new policies and procedures under the Preferred Alternative.

The effect of the proposed changes to the policy and procedures on the forest environment can be summarized as:

- changes in forest conditions as measured by the forests standing volume and stand development stages, and
- changes in the amount of disturbance or area under harvest activities.

The environmental effects of each of the proposed policy and procedural changes are examined for differences between Alternatives and differences in short- or long-term effects.

Sustainable, Even-Flow Timber Harvest

All Alternatives, except Alternative 1, propose to ease the sustainable even-flow policy. This policy directs DNR on how to meet its objective of revenue generation over the long term. The policy choices are a restricted flow policy (Alternatives 1 and 4), a non-declining policy (Alternative 2), a modulating timber flow policy (Alternative 5 and the Preferred Alternative), and a policy that essentially provides no constraint on the harvest flow (Alternative 3).

Changes in standing inventory are presented in Table 4.2-7 for all the Alternatives. All Alternatives, including Alternative 3, demonstrate an increase in standing volume over time (ensuring timber yields for future generations) and a more-diverse forest in terms of structural conditions (Table 4.2-8). In Appendix D, Table D-8, stand structural development over time is presented for individual HCP Planning Units.

Table 4.2-6. Policy, Procedure, and Operational Changes that Affect Forest Structure, Growth, and Yield

Policy and Procedure Changes Proposed	Alternative					
	1	2	3	4	5	PA
Policy No. 4 – Sustainable, Even-Flow Timber Harvest		X	X	X	X	X
Policy No. 6 – Western Washington Ownership Groups			X		X	X
Policy No. 5 – Harvest Levels Based on Volume					X	X
Procedure 14-004-120 – Management Activities within Spotted Owl Nest Patches, Circles, Designated Nesting, Roosting, and Foraging and Dispersal Management Areas		X	X	X	X	X
Policy No. 30 – Silviculture Activities; Policy No. 31 – Harvest and Reforestation Methods						X

X = indicates a proposed change in the policy or procedure
PA = Preferred Alternative

Table 4.2-7. Change in Standing Volume from Base Year 2004 by Alternative through 2067 (billion board feet)

Year Modeled	Alternative					
	1	2	3	4	5	PA
2004	31	31	31	31	31	31
2013	35	34	33	35	32	32
2031	46	41	38	45	34	37
2067	60	50	46	58	41	45

PA = Preferred Alternative
Source: Model output data (stand development stages).

Table 4.2-8. Comparison of Forest Stand Development Stage Distribution (percent of forested acres) in 2067

Forest Stand Development Stage	Existing Condition (2004)	Alternative					
		1	2	3	4	5	PA
Ecosystem Initiation	8%	9%	10%	11%	8%	11%	11%
Sapling Exclusion	17%	2%	3%	4%	1%	2%	5%
Pole Exclusion	21%	18%	26%	29%	18%	33%	21%
Large Tree Exclusion	16%	10%	10%	9%	14%	9%	10%
Understory Development	14%	35%	25%	22%	32%	21%	24%
Botanically Diversity	23%	21%	21%	20%	22%	21%	19%
Niche Diversification	<1	2%	2%	2%	2%	1%	5%
Fully Functional	1%	3%	3%	3%	3%	1%	5%

PA = Preferred Alternative
Source: Model output data (stand development stages).

The effects on forest condition appear positive for all the Alternatives over the long term. The distribution of harvest area across forested trust lands in western Washington, and therefore short-term impacts, may differ among the Alternatives. This aspect is examined in more detail in the Harvest Area section of Section 4.2.

Model outputs suggest most Alternatives would maintain a relatively constant timber harvest volume and timber area over the planning period 2004 through 2067 (Figures 4.2-1 and 4.2-2, respectively). Alternative 5 has a higher harvest area in the first half of the planning period and then the harvest area reduces to a similar level as the other Alternatives. This higher harvest level is predominantly thinnings (Figure 4.2-3). Alternative 3, which produces the most variation in the first half of the planning period, begins to produce a steadier flow towards the end of the planning period.

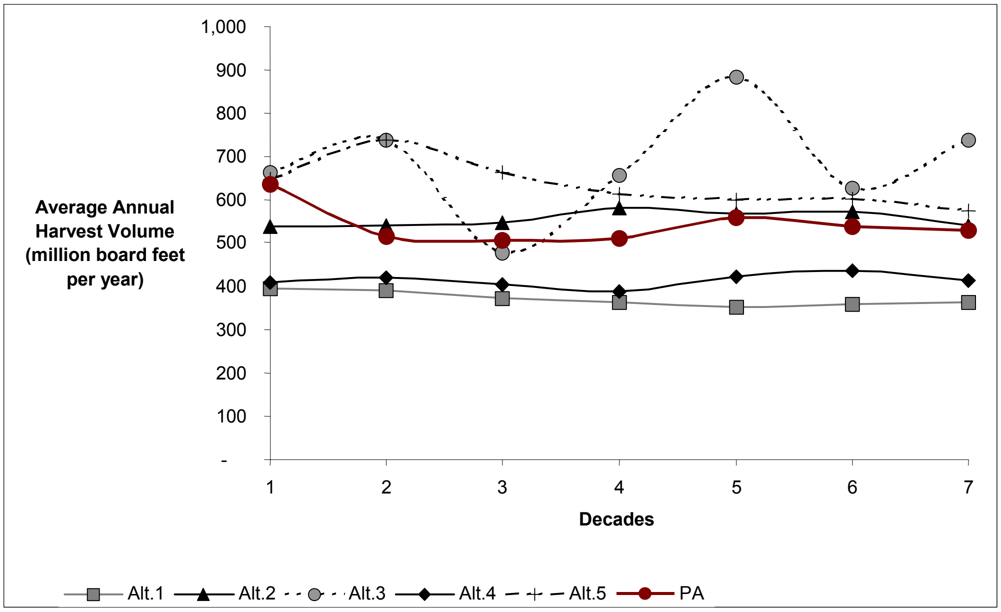

Figure 4.2-1. Average Annual Western Washington Forested State Trust Land Timber Harvest Volume per Decade over the Planning Period (2004-2067)

PA = Preferred Alternative
Data Source: Model output data – timber flow levels.

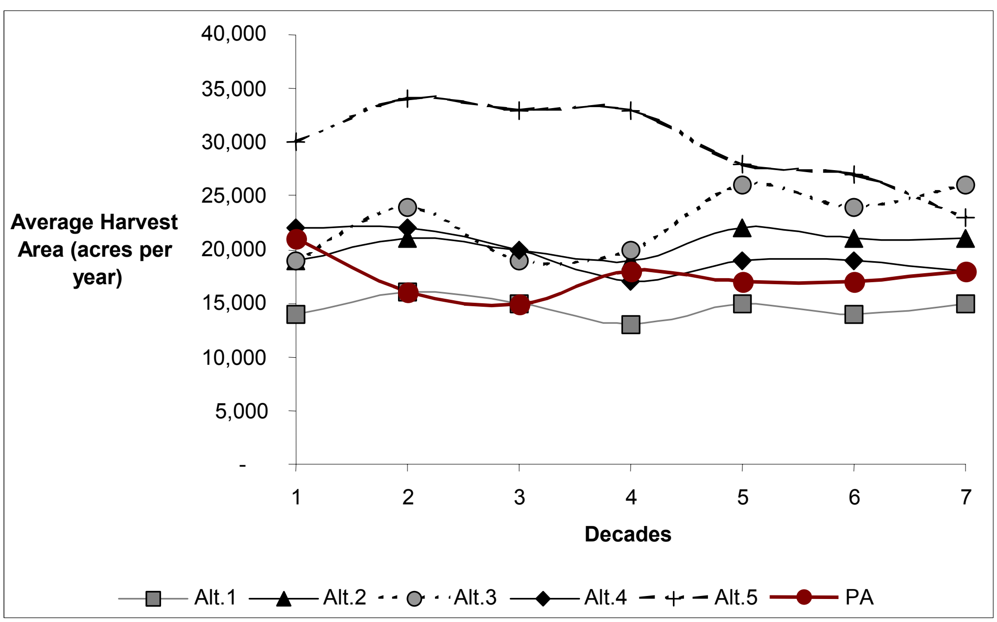

Figure 4.2-2. Average Annual Western Washington Forested State Trust Land Timber Harvest Area per Decade Over the Planning Period (2004-2067)

PA = Preferred Alternative
Data Source: Model output data – timber flow levels.

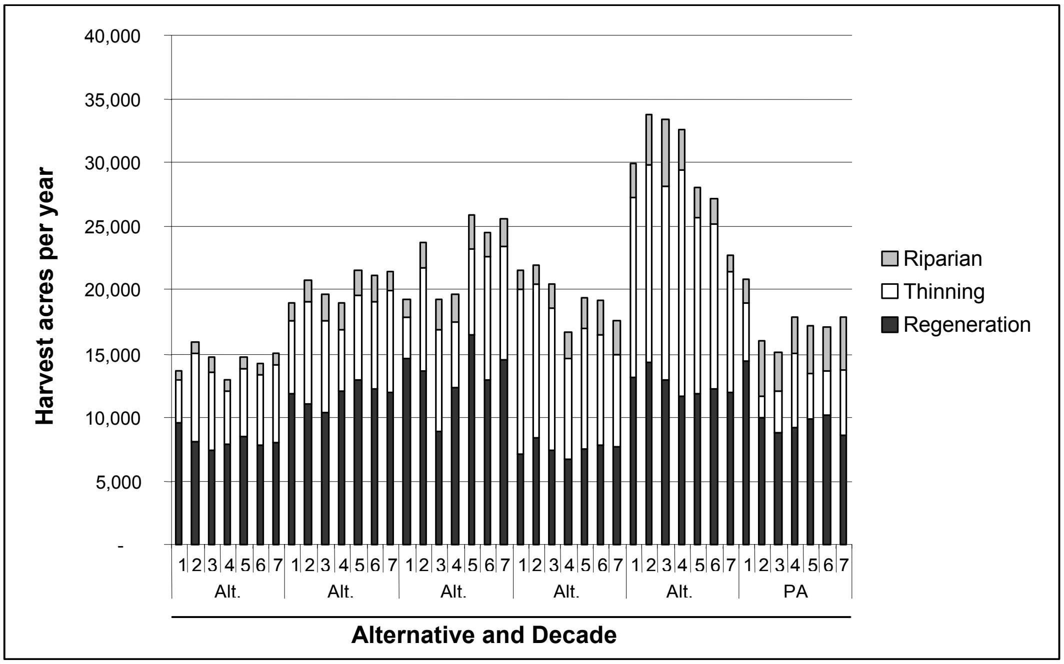

Figure 4.2-3. Harvest Type and Area by Alternative
PA = Preferred Alternative
Data Source: Model output data – timber flow levels.

Western Washington Ownership Groups (renamed as Sustainable Harvest Units, see Appendix F)

Policy choices that determine the size (area) of the management unit on which a sustainable even-flow of timber is managed can affect not only the total amount of harvest at any one time, but also the harvest distribution across the forested trust lands in western Washington. The policy choices considered in the Alternatives are: maintaining the sustainable harvest units (Ownerships Groups, Forest Resource Plan Policy No. 6) at 24 units; reducing the number to 20 by grouping all the federally granted trusts into one westside sustainable harvest unit, or eliminating all the sustainable harvest units and grouping all trusts into one westside sustainable harvest unit.

The reduction in sustainable harvest units is expected to increase the available harvest area, as synergies of available merchantable volume may occur between existing units and could be realized. The increase in harvest area may also be accompanied by an increase in the concentration of harvests in a particular geographical region over time. Therefore, a policy of one westside sustainable harvest unit might be expected to express these trends the most. However, other policy and management strategies may tend to limit the expected effects of an increase in sustainable harvest unit size. The combination of Habitat Conservation Plan management goals, such as riparian management and the protection of public resources (e.g., management of slope instability), results in a DNR-managed forest landscape where approximately:

- 31 percent of the land is within a Riparian and Wetlands Management Area,
- 43 percent is within a Upland Area where management will result in extended rotations and/or the maintenance of a portion of a forest canopy, and
- the remaining 26 percent is forestland that is managed with a primary focus on revenue generation (Table 4.2-9).

Therefore, the combined effects of the DNR's revenue generation and habitat conservation policy goals are likely to sufficiently limit the effects of the reduction in the number of sustainable harvest units.

Harvest Levels Based on Volume

Harvest levels can be calculated using either volume or value to represent forest growth. Either choice is consistent with the law (Revised Code of Washington 79.10.340). If this policy decision on how to calculate the harvest level were considered in isolation (i.e., no change in other policies), the choice may be expected to produce differences in forest conditions in terms of standing volumes. A policy that uses a volume calculation method (Alternatives 1 through 4) would likely be reflected by silvicultural and harvest regimes that increase volume. The standing inventory may be expected to increase over time as rotation lengths extend to maximize volume. A value-based method (Alternative 5 and the Preferred Alternative) may be expected to reduce standing volume over time, as rotation lengths reflect an economic rotation. However, this policy choice is not considered in isolation of other policies, particularly silviculture.

Table 4.2-9. Land Classes for Westside Habitat Conservation Plan Planning Units

HCP Planning Unit	Riparian and Wetlands		Uplands with Specific Objectives		Uplands with General Objectives		Total
	Acres	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**
Columbia	86,400	32%	99,500	37%	81,600	31%	**267,500**
North Puget	92,700	24%	205,000	54%	83,800	22%	**381,500**
OESF	111,300	43%	145,200	57%			**256,500**
South Coast	81,000	35%	36,700	16%	115,300	49%	**233,000**
South Puget	34,600	24%	82,100	58%	25,200	18%	**141,900**
Straits	20,700	19%	32,900	30%	56,800	51%	**110,400**
Total[1/]	**426,700**	**31%**	**601,300**	**43%**	**362,700**	**26%**	**1,390,700**

Note: the Olympic Experimental State Forest (OESF) is an "unzoned" approach; therefore, there are no acres of Uplands with General Objectives.

1/ Acreage totals include lands in both short-term and long-term deferral status. This contrasts with other places in the document where acreages may not include short- and long-term deferral lands.

For Alternative 5 and the Preferred Alternative the silvicultural regimes are designed to increase the net present value of the forest stand subject to other objectives, as applicable. On Uplands with General Objectives, the expected effects may be a reduction in standinginventory, a younger age class distribution, and a higher percentage of ecosystem initiation forest. The modeling outputs (Table 4.2-10) support this trend for Alternative 5. Alternative 3 also demonstrates a similar trend, but this is related more to the level of harvest, which is influenced by the flow constraint and type of harvest than to the method of calculation.

Silviculture Activities

The choice of silviculture systems and treatments has the potential to influence forest conditions at multiple scales, both temporal and spatial. In general, all the Alternatives assume a continuation of the forest practices of even-aged plantation forestry on portions of forested trust lands in western Washington. The exceptions to this general statement are the silvicultural regimes to be developed for Riparian Management Zones and resource sensitive areas, such as visual areas and areas of slope instability. In these areas, it is more likely that DNR would develop silviculture prescriptions based on un-even aged silvicultural systems.

The Preferred Alternative provides policy direction to DNR to implement biodiversity pathway approaches to silviculture on forested trust lands. The other Alternatives essentially maintain the status quo on the type of silviculture to be implemented (Alternative 1, 2, and 3), use more-intensive silviculture (Alternative 5), or use even-aged silviculture with longer rotations (Alternative 4). The Preferred Alternative focuses the implementation of biodiversity pathway approaches on Riparian and Wetland Management Areas and the upland areas designated for habitat management (Olympic Experimental State Forest; nesting, roosting, foraging, and dispersal areas). The modeling results for stand development stages illustrate the increase in structurally complex forest for the Preferred Alternative compared to the other Alternatives (see Figure 2.6-4).

Table 4.2-10. Percentage Change in Standing Forest Inventory in the Uplands with General Objectives between 2004 and 2067

Alternatives	Percent Standing Volume change	Percent Area Change in Ecosystem Initiation
Alt.1	24%	76%
Alt.2	26%	54%
Alt.3	-10%	100%
Alt.4	12%	76%
Alt.5	-9%	14%
Preferred Alternative	21%	47%

Notes:
Current standing inventory is estimated at 8 billion board feet.
Current area of Ecosystem Initiation is estimated at 39,563 acres.

A key silvicultural principle of biodiversity pathways is to replicate some of the natural processes by removing more trees from the stand than in a traditional thinning, thereby allowing for light and water to encourage growth of understory tree species and other flora.

Depending upon stand conditions, the combination of thinning for variable residual tree densities, underplanting, vegetation management, and the recruitment of snags and coarse woody debris is thought to "accelerate" the development of complex structural conditions in second-growth forests. Exact treatments are dependent upon the stand objectives and site conditions. For example, forest stands that have a lot of tall trees in them with small crowns (dense tall stands) are probably not suitable for thinnings that remove a lot of trees at once (heavy thinnings). However, a combination of removing less trees (lighter thinning) and patch cuts (1/2 to 10 acres in size) may result in a forest stand that has improved future structures as the patches provide opportunity for understory trees to develop.

While biodiversity pathways approaches to silviculture are designed to promote a stand's structural development, implementation of these treatments is likely to be limited by current stand conditions. Analysis of current forest conditions of the riparian-wetland and designated habitat management areas (770,000 acres) suggests that only about 35 percent (270,000 acres) is suitable for long-rotation (140-year) silviculture with variable-density thinnings. Suitability is defined here as conifer-dominated stands that are not in a densely overstocked state. Variable-density thinnings, with heavy thinning treatments in dense and especially dense-tall mature stands can be problematic. Removing a large number of trees from an overly stocked stand to promote understory development may severely increase the risks of catastrophic blowdown and collapse of the stand. In these cases, other stand-level prescriptions would be developed. For example, lighter thinnings that maintain more of the overstory could be used in combination with patch-cutting. For specific stands, regeneration harvest may be the appropriate option. In practice, for riparian and designated habitat management areas, DNR forest managers design site-specific prescriptions to meet Habitat Conservation Plan objectives that account for current conditions.

The forested trust lands in western Washington are dominated by second-growth even-aged stands (see Figure 2.6-2). The majority of this forestland is dominated by single-canopy stands with little diversity in tree size or species. These stands are in a competitive exclusion stage. If these stands were left to develop along nature's path (i.e., with no human management), it is unlikely that many would develop into multiple-story structurally complex stands over the life of the Habitat Conservation Plan. Franklin et al. (2002) suggested that competitive exclusion in Douglas-fir/western hemlock forests could be maintained for 100 years or more. One-hundred-year simulations of DNR's forest inventory using the USDA Forest Service Forest Vegetation Simulator demonstrated little change in the forest structure in terms of the area with multiple tree strata (see Appendix B, Section B.2.2). This is because it takes a long time for nature to lower the number of dominant canopy trees per acre through natural mortality alone to a level where the remaining trees can grow to a large size and other trees can then develop under the upper canopy.

Even-aged silvicultural systems, in general, are designed to maintain stands in a competitive exclusion state to maximize volume production per unit area. Therefore, these systems do not necessarily encourage the development of structurally complex forests. Even-aged silviculture maintains the live tree density too high for the development of a functional understory. In addition, some "mortality" that would have been expected as snags or coarse woody debris is removed during thinning. These thinnings are typically designed to maintain the health and vigor of the residual growing trees as they get larger over time.

Shorter rotations as in Alternative 5 may be expected to develop a younger forest over time. Longer rotations, as in Alternatives 4 and the Preferred Alternative, may be expected to develop an older forest over time. Longer rotations and older forest stands do not guarantee that the forest will become more structurally complex. However, longer rotations do provide more time between disturbances, which may be important for certain flora and fauna.

Harvest Area

The combination of policy and procedural changes presented in the six Alternatives would likely result in differing disturbance regimes (i.e., amounts of area harvested) among the HCP Planning Units. Equally, if a smaller scale is used (e.g., watershed), then differences among Alternatives might be expected to be more noticeable. While the forest modeling used to inform the Board of Natural Resources' policy analysis and this Final EIS are not designed to produce a site-specific harvest schedule for each forest stand in western Washington forested trust lands over the next decade, the modeling outputs can be used to provide a level of information on the likely harvest level at the watershed scale. The modeling results report only one possible outcome. DNR forest managers will design actual harvest schedules. It is reasonable to expect that there will be differences between the processes. Using the modeled outcomes for this Final EIS analysis provides a picture of the relative differences between Alternatives in terms of the variation of possible harvest regimes at the HCP Planning Unit and watershed scale. It does not provide a meaningful schedule of harvest events.

DNR manages forested trust lands in 324 watersheds in western Washington. Watersheds are represented here by the April 2002 Washington Department of Ecology Watershed Administrative Unit Geographic Information System coverage and provide a convenient spatial scale at which to conduct this analysis. Trust ownership in these 324 watersheds varies from 1 acre (0.003 percent of the watershed area) to 56,800 acres (98 percent of the watershed area). To simplify this analysis, only the watersheds in the upper quartile of percent ownership are considered. The threshold, the upper quartile, requires that 22 percent or more of the land in the watershed be DNR-managed forested trust lands. Eighty-three watersheds meet that ownership threshold, and they represent approximately 68 percent (944,000 acres) of all the forested trust land ownership in western Washington.

The impact of a decade's cumulative regeneration harvest activity in these 83-watersheds is presented in Table 4.2-11. As expected, the Alternatives result in differing levels of areas harvested. The decadal cumulative level of activity is described in three categories: less than 10 percent, between 10 and 20 percent, and more than 20 percent of the forested trust land in the watershed is regenerated over a decade. The groupings are somewhat arbitrary; however; the group of "more than 20 percent" represents approximately 5 percent of the regeneration harvest area in decade 1.

Table 4.2-11. Number of Watersheds[1/] with Rates of Regeneration Harvests for each Alternative over Seven Decades

Decade	Level of Regeneration Harvest Activity (percent[2/])	Alternatives					
		1	2	3	4	5	PA
	1-9	46	36	38	36	7	25
1	10-20	27	33	27	23	33	32
	>20	8	12	16	23	42	23
	1-9	41	24	25	32	4	33
2	10-20	32	40	31	27	24	44
	>20	9	18	26	22	53	4
	1-9	47	17	20	31	2	31
3	10-20	30	57	56	32	29	49
	>20	5	8	6	19	51	2
	1-9	52	28	21	29	3	25
4	10-20	25	43	51	47	22	51
	>20	5	10	10	6	57	5
	1-9	41	16	11	29	3	29
5	10-20	35	55	40	37	51	45
	>20	6	11	31	16	28	7
	1-9	41	19	17	26	8	30
6	10-20	33	48	40	40	42	43
	>20	7	14	24	15	31	8
	1-9	75	73	64	75	64	76
7	10-20	3	9	18	6	16	5
	>20	0	0	0	0	0	0

Notes:

1/ Values presented in the table represent watersheds where forested trust lands ownership equals 22 percent or greater of the watershed area and regeneration harvests occur in the decade. Some watersheds do not have harvests in them in a given decade; therefore, the totals will not add up to 83 watersheds, as discussed in Chapter 4, Section 4.15.

2/ The level of harvest activity is expressed as a percentage of the forested trust lands ownership acreage in a watershed that is regenerated over a decade period.

PA = Preferred Alternative

Data Source: Model output data – timber flow levels.

Alternative 5 is projected to have the highest level; regeneration harvest levels of more than 20 percent of the watershed would affect 42 watersheds in decade 1 (Table 4.4-11). Alternative 1 and 2 are projected to have the lowest number of watersheds (8 and 12, respectfully), while the Preferred Alternative (23) and Alternative 3 (16) and 4 (23) have an intermediate number of watersheds with more than 20 percent of the watershed affected by regeneration harvest. This trend between the Alternatives is generally repeated over the seven decades, with the exception of the Preferred Alternative, which after the first decade is projected to have fewer watersheds in the "more than 20 percent" regeneration group. This trend for the Preferred Alternative may be due to the high level of regeneration harvest in stands that are not suitable for long rotation biodiversity management in the first decade. Similar patterns and trends among the Alternatives are projected at the HCP Planning Unit scale (see Appendix D.1).

While the above analysis identifies the potential for relatively high harvest rates in some watersheds, the combination of DNR's policies of habitat conservation (Riparian Management Zones and designated habitat management areas) and protection of public resources applies to all watersheds. For example, riparian and wetland areas and areas of slope instability are managed with the same objectives as are watersheds that receive lesser harvest. The distribution of land classes by watershed is presented in Appendix E, Section E.1. The relative risks of the short-term impacts are identified and assessed at further planning levels and at the project level. Analysis of the type above and in the Cumulative Effects section (Section 4.15) will assist in focusing mitigation and planning efforts on the watersheds that could potentially receive relative high harvest levels.

4.2.5 Old Forest

4.2.5.1 Affected Environment

There is no single definition of an old forest, sometimes referred to as old growth. Depending on the definition of these terms, the extent and value of the forest varies. For some individuals, the definition of old forest is deeply rooted in science; for others, old forest simply means big trees. To many people, old forests have spiritual or aesthetic values or are important for recreation. The intangible benefits of old forest will be the focus of this subsection, and will be measured by the presence of stands with old forest characteristics. Refer to Section 4.4 (Wildlife) for a discussion of old forest as wildlife habitat.

In this section, various definitions to describe old forests are used, which include:

- Forest stands older than 150 years of age; and
- Forest stands that have various old forest characteristics, labeled here as "structurally complex" forests, which include botanically diverse, niche diversification, and fully functional stand development stages (Table 4.2-4).

In the Olympic Experimental State Forest, 20 percent of forested trust lands are managed for old forest conditions (DNR 1997, page IV.88). While the term is not used in this analysis, the Habitat Conservation Plan glossary provides the following definition for old-growth forest.

A successional stage after maturity that may or may not include climax old-growth species; the final seral stage. Typically contains trees older than 200 years. Stands containing Douglas fir [*sic*] older than 160 years, which are past full maturity and starting to deteriorate, may be classified as old forest. DNR's GIS forest classification for old forest is: a dominant DBH (diameter at breast height) of 30 inches or greater; usually more than eight dominant trees/acre; three or more canopy layers with less than complete canopy closure; several snags/acre with 20 inch dbh or greater; and several down logs per acre with a 24 inch dbh or greater."

According to Forest Resource Plan Policy No. 14, about 2,000 acres of old forest (stands larger than 80 acres and greater than 160 years old) are currently deferred from timber harvest in Old Growth Research Areas

DNR estimates there are about 341,000 acres of structurally complex forests on western Washington forested state trust lands. The distribution of these structurally complex acres among the HCP Planning Units is provided in Table 4.4-1. Field observations and local research indicate some level of agreement with these estimates; however, the criteria used to identity old forests and structural complexity will vary depending upon the purpose. DNR's stand development stage classification uses criteria principally from studies in the western hemlock/Douglas-fir forests and may not accurately categorize other forest types, for example the spruce forests in the Olympic Experimental State Forest.

4.2.5.2 Environmental Effects Associated with Old Forest

Proposed changes to policy and procedures among the Alternatives that would affect old forest are summarized in Table 4.2-12.

All Alternatives, with the exception of Alternative 5, show an increase in the area of old forest conditions over the 64-year planning period. Figure 4.2-4 graphically displays the distribution of structurally complex forest at the end of the planning period. Figure 4.2-5 displays acres of forests 150 years old or greater occurring at the end of the first and last decades of the analysis period.

Table 4.2-12. Policy and Procedure Changes that Affect Old Forest on Forested Trust Lands

Policy Change Proposed	Alternative					
	1	2	3	4	5	PA
Procedure 14-006-090 – Legacy and Leave Tree Levels		X	X	X	X	X
Manage 10-15% of each Planning Unit in Mature Forest Component					X	X
Maintain All Stands Greater than 150 Years Old				X		

PA = Preferred Alternative

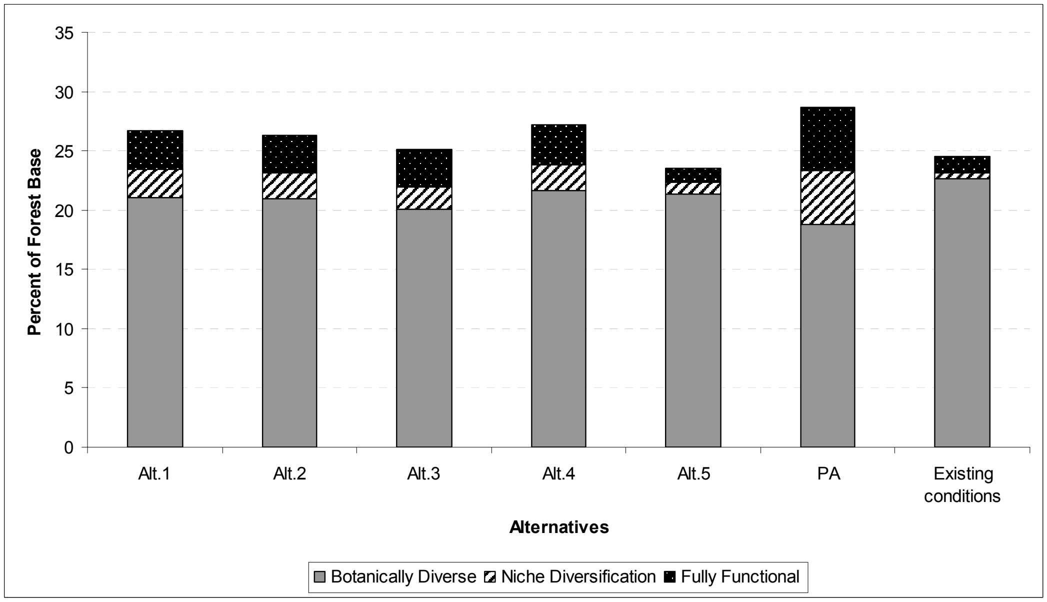

Figure 4.2-4. Percent Distribution Structurally Complex Forest at Year 2067
PA = Preferred Alternative
Data Source: Model output data – stand development stages

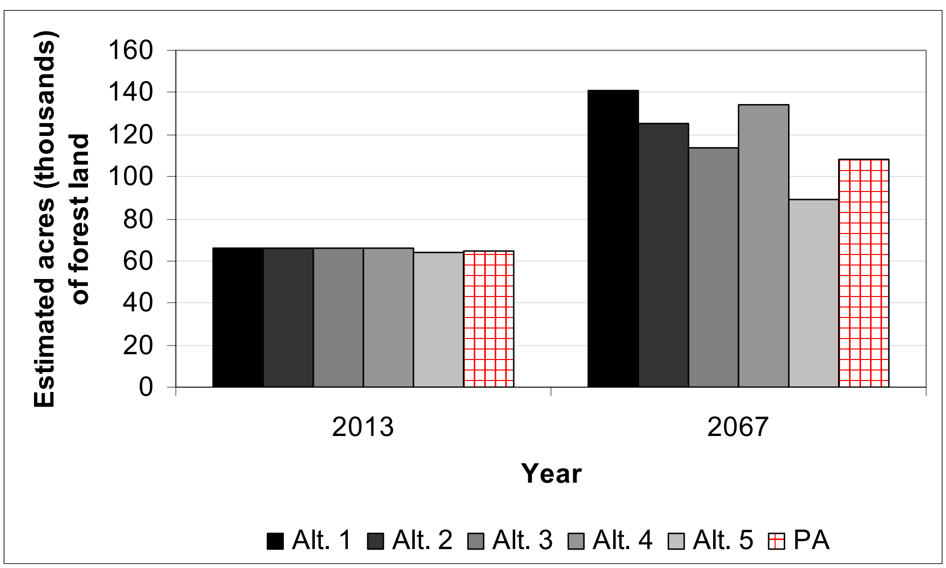

Figure 4.2-5. Acres of Forests 150 years and Greater by Alternative at Years 2013 and 2067

Note: Current conditions estimated at 60,000 acres of old forest are represented as forests 150 years and greater.
PA = Preferred Alternative
Data Source: Model output data – stand development stages.

Alternatives 1, 2, 3, 4, and the Preferred Alternative all show that the increase in the amount of structurally complex forest over the planning period is not large: between 2 percent for Alternative 3 and 17 percent for the Preferred Alternative. The Preferred Alternative also increases the area of forest in a fully functional condition. This most likely is the result of silvicultural treatment associated with biodiversity approaches. Alternative 5 displays a slight decrease in structurally complex forests. This is mostly the result of the combination of large harvest areas in the first half of the planning period and shorter rotations. The modeling results for Alternative 5 suggest that over the planning period structurally complex conditions could actually be lost due to harvesting. However, in practice with a policy of targeting 10 to 15 percent of each HCP Planning Unit's forested trust lands to be in structurally complex forest, it is unlikely that any area would be lost. DNR field foresters would most likely target existing older and more structurally complex stands for a no harvest regime.

In terms of forest area at or greater than 150 years of age, Alternative 5 and the other Alternatives all demonstrate increases in areas (Figure 4.2-5). The increase in forest area with a stand age of 150 years or more is greatest in Alternatives 1 and 4 compared to the other Alternatives. Both these areas have less on-base acres and less area under harvest in any decade compared to the other Alternatives (Figure 4.2-5). Alternative 4 also provides protection to all existing stands over 150 years of age. Alternative 1, however, demonstrates the effect of maintaining a large part of the land base off-base as an effective mechanism for developing an older forest. Alternatives 2, 3, and the Preferred Alternative demonstrate less acreage in 2067 in forest area over 150 years of age than Alternative 1. For Alternatives 3, 5, and the Preferred Alternative, the differences are approximately 27,000, 52,000, and 34,000 acres.

4.2.6 Forest Health

4.2.6.1 Affected Environment

Forest Resource Plan Policy No. 9, Forest Health, and Guideline 14-004-030, Assessing and Maintaining Forest Health, both incorporate forest health practices into forest management, stressing prevention through early detection and management such as the maintenance of appropriate species and tree density in state forests.

Growing space is the sum of conditions needed for tree growth. Relative density indicates the amount of growing space occupied by each tree within a forest stand (relative density is a ratio based on a sampling of tree measurements). Often used as a tool to determine when thinning is needed to maintain steady stand growth, relative density can also be used as an indicator of stand health. As competition among trees for growing space increases, relative density increases and vigor for some trees decline.

Increased susceptibility to insects and disease in densely stocked forest stands is, in part, a function of the way a tree allocates its food resources or nutrients. Although allocation of food may vary among tree species and different tree ages, most trees have a set priority for allocating resources. Maintenance of the tree's existing living tissue (tree growth) and reproduction are of higher priority than the production of resistance mechanisms to ward off insects and disease (Oliver and Larson 1996). High density does not ensure poor stand health, because it is not specifically the cause of stress and mortality. Insects, disease, and environmental factors that cause mortality may affect a stand at any time. However, forest stands with decreased vigor are more susceptible to these stresses (Drew and Flewelling 1979). The point at which density-caused mortality occurs serves as an indicator of forests at increased risk for forest health concerns.

The relative density at which competition-related mortality occurs varies by tree species.

- Western hemlock and Douglas-fir trees dominate the majority of the forest stands on forested trust lands.
- Douglas-fir dominated stands begin to experience density-related mortality at a relative density of 50, although some stands do not show mortality until they reach a relative density of 70 (Curtis 1982; Bailey et al. 1998).
- Western hemlock stands begin to experience density-related mortality at a relative density of 55 (USDA Forest Service 2002a).
- Red alder stands begin to experience density-related mortality at a relative density of 44 (Puettmann et al. 1993).

Table 4.2-13 shows the relative density level when the susceptibility for competitive mortality increases for the three major tree species in western Washington forested state trust lands. Approximately 459,000 acres of Douglas-fir stands, 331,000 acres of western hemlock stands, and 82,000 acres of red alder stands are nearing or at increased risk to mortality, based on elevated relative density. Thinning to maintain growth also increases stand vigor.

The 2002 aerial survey showed that the major causes of damage in western Washington forests include hemlock looper and black bear (DNR 2003). Hemlock looper is a tree defoliator that is associated with multi-storied old forest. Its primary hosts are western hemlock, Douglas-fir, and western red cedar. Outbreaks of hemlock looper have been quite extensive in recent years, presumably due to drought.

Table 4.2-13. Forests at or Above the Relative Density Levels at Which Tree Mortality Occurs by Tree Species

Major Dominate Tree Species	Relative Density When Density-Related Mortality May Begin	Acres on Forested Trust Land	Percent of Total Forested Area
Douglas-fir	50 and above	459,000	33
Western hemlock	55 and above	331,000	24
Red alder	44 and above	82,000	6
Total		**872,000**	**63**

Data Source: Model output data (stand development stages).

Black bear damage increased from about 38,000 acres in 2001 to 172,000 acres in 2002. Damage to sapling and pole-sized stands can be high. Bears strip the bark to eat the cambium layer, reducing stand growth and introducing stem decay. Laminated root rot poses a major threat to its most economically important host, second-growth Douglas-fir. The disease causes root decay, which can cause significant growth reduction, and makes trees susceptible to blowdown (Thies and Sturrock 1995). Recently cut stumps are infected by spores. The disease can remain viable for decades in old stumps and roots. Thinning can worsen the problem, causing the disease to spread to uninfected trees. Black-stain root disease is spread by insects, primarily root-feeding bark beetles such as *Hylastes nigrinus*. Trees damaged by logging operations, including thinning, have an increased risk of infection. Soil compaction may also play a role (Otrosina and Ferrell 1995). Treatment of root disease generally is by removing the diseased trees. The area is typically then reforested with a less susceptible tree species (DNR 1997).

Bark beetles are usually associated with events that kill or weaken trees, such as windthrow or drought. When populations increase, bark beetle will attack healthy trees.

Fire Risk

The operation of logging equipment can ignite a forest fire, especially when surface fuels (slash) associated with logging are present. Additionally, intensive management requires greater access, which may lead to increases in human-caused fires. Fire intensity and expected fire spread rates increase in areas adjacent to harvest. This analysis uses the level of harvest intensity by Alternative to evaluate fire risk.

4.2.6.2 Environmental Effects Associated with Forest Health

There are no proposed changes in policy, procedures, or tasks among the Alternatives that specifically address forest health. However, proposed policy changes that affect harvest intensity and, consequently, forest structures across the landscape can affect forest health. (Refer to Appendix D for a discussion on harvest intensity.)

Under Alternatives 1, 2, and 4 there would be a slight increases in the acres of forest stands with a high relative density (Table 4.2-14). Only Alternatives 3, 5, and the Preferred Alternative illustrate any reduction in area of stands with high relative density. Intensive management that includes regeneration harvest and aggressive thinning strategies under Alternative 5 would result in the greatest reduction of acres with high relative densities (Table 4.2-15).

The high levels of moderate to heavy thinning associated with Alternative 5 and the Preferred Alternative could increase the risk of tree mortality and growth loss from root disease (Thies and Sturrock 1995) and windthrow if harvest is not properly designed and implemented. Bark beetle tree mortality is generally associated with weakened or dead trees. Windthrow would increase the risk of beetle population increases and consequent tree mortality from bark beetles. Therefore, additional resources and staff would need to be committed to ensure that harvests are carefully planned and administrated.

Table 4.2-14. Percent of Total Forested Acres with Elevated Relative Density Levels over the Planning Period by Alternative[1/]

Alternative	Dominant Tree Species	Analysis Period 2004	2008	2013	2031	2048	2067
1	Douglas-fir	33%	34%	37%	38%	33%	34%
	W. Hemlock	24%	29%	30%	31%	24%	29%
	Red Alder	6%	6%	5%	5%	6%	6%
	Total Acres	**63%**	**68%**	**72%**	**73%**	**63%**	**68%**
2	Douglas-fir	33%	32%	37%	36%	33%	32%
	W. Hemlock	24%	28%	28%	28%	24%	28%
	Red Alder	6%	6%	5%	5%	6%	6%
	Total Acres	**63%**	**66%**	**70%**	**69%**	**63%**	**66%**
3	Douglas-fir	33%	30%	32%	33%	33%	30%
	W. Hemlock	24%	29%	26%	28%	24%	29%
	Red Alder	6%	6%	5%	5%	6%	6%
	Total Acres	**63%**	**65%**	**64%**	**66%**	**63%**	**65%**
4	Douglas-fir	33%	34%	37%	36%	33%	34%
	W. Hemlock	24%	28%	29%	29%	24%	28%
	Red Alder	6%	5%	5%	5%	6%	5%
	Total Acres	**63%**	**67%**	**70%**	**70%**	**63%**	**67%**
5	Douglas-fir	31%	28%	27%	30%	31%	28%
	W. Hemlock	24%	28%	23%	27%	24%	28%
	Red Alder	6%	5%	5%	4%	6%	5%
	Total Acres	**61%**	**60%**	**55%**	**61%**	**61%**	**60%**
Preferred Alternative	Douglas-fir	33%	31%	34%	28%	33%	31%
	W. Hemlock	24%	25%	26%	26%	24%	25%
	Red Alder	6%	5%	3%	6%	6%	5%
	Total Acres	**63%**	**61%**	**63%**	**60%**	**63%**	**61%**

[1/] See Table 4.2-13 for relative density levels when tree mortality occurs by tree species.
Data Source: Model output data - stand development stages.

Table 4.2-15. Harvest in Riparian Zones and Percent of Forest with Botanical Diversity, by Alternative

Alternative	Average Percent of Riparian Land Class Impacted per Decade by Harvest Type: Low Volume Removal Harvest [1/]	Medium Volume Removal Harvest[2/]	High Volume Removal Harvest[3/]	Total	Percent of Forested Acres (Upland and Riparian) with Botanical Diversity[4/] in 2067
1	1	0	1	2	30
2	1	0	3	4	30
3	1	0	3	5	29
4	2	1	2	5	30
5	4	0	3	7	29
PA	1	2	6	8	33

Data Source: Model output data – timber flow levels and stand development stages.
1/ Less than 11 thousand board feet per acre volume harvests
2/ Between 11 and 20 thousand board feet per acre volume harvests
3/ Greater than 20 thousand board feet per acre volume harvests
4/ Includes botanically diverse, niche diversification, and fully functional forest stages
PA = Preferred Alternative

The risk for hemlock looper outbreak may increase slightly under all Alternatives because all Alternatives promote multi-layered canopy forest structure; however, looper is generally associated with old forests and drought (DNR 2003).

Alternatives that feature thinning entries (such as Alternative 5 and the Preferred Alternative) could increase the risk of diseases spread through wounds made by logging equipment (Otrosina and Ferrell 1995).

Alternatives that have the greatest amount of forest in the sapling and pole exclusion stages would have the greatest risk for bear damage. At the end of the planning period (2067), Alternatives 1 and 4 would have the least area at risk of bear damage, with 20 and 19 percent of the forested trust lands in sapling and pole exclusion stands, respectively (Table 4.2-8). Alternatives 2, 3, 5, and the Preferred Alternative would have a greater percent of the area in these stand development stages—between 26 and 35 percent of forested trust lands would be in sapling and pole exclusion stand development stage at the end of the planning period.

Fire Risk

Harvest intensity under Alternatives 1, 2, and 4 would be relatively low. The risk for wildfire associated with operator fires and logging residue would be similar to the existing risk under these Alternatives. Harvest intensity under Alternative 3 would fluctuate over time. Regeneration harvest would be higher than the other Alternatives in the first decade but would decrease over time. Fire risk under Alternative 3 would be highest in those years when harvest intensity is high (Appendix D). Alternative 5 and the Preferred Alternative would have the highest harvest intensity levels over the duration of the planning period, with Alternative 5 slightly higher than the Preferred Alternative. The higher number of harvested acres would increase the risk of a fire compared to the other Alternatives. Under all Alternatives, fire risk would be mitigated by treatment of logging slash after the timber has been harvested if it is determined to be an extreme hazard (DNR 1992b). Slash treatments are designed to burn, remove, or rearrange the slash to reduce fire risk. In periods of high fire risk, logging operations are normally suspended, thereby mitigating fire risk during logging operations.

4.2.7 Carbon Sequestration

Carbon, primarily in the form of carbon dioxide, is one of the major greenhouse gases that are being released into the atmosphere (McPherson and Simpson 1999). The global carbon cycle involves the earth's atmosphere, fossil fuels, the oceans, and the vegetation and soils of the earth's terrestrial ecosystems. Gases that make up the earth's atmosphere, such as carbon dioxide, methane, nitrous oxide, and water molecules, trap the sun's heat, creating a natural "greenhouse effect" that makes life on earth possible (McPherson and Simpson 1999). These gases are released into, and removed from, the atmosphere by a variety of natural sources and sinks.

Forestlands have the capacity to absorb large quantities of carbon dioxide emissions and sequester carbon for potentially long periods of time (Binkley et al. 1997). Forests have the potential to store a great deal more carbon than they currently do (Harmon 2001), which, in turn, may temporarily slow the increase of atmospheric carbon dioxide concentrations. Although studies have shown that intensive forest management can lead to increased rates of carbon dioxide sequestration (Schroeder 1991; Binkley et al. 1997), other research suggests that not all forestry-related projects are equally likely to sequester carbon and that some may actually release carbon to the atmosphere (Harmon 2001).

The term “carbon sequestration” refers to the removal of carbon dioxide from the atmosphere, and the long-term storage of carbon as trees or as products such as lumber (U.S. Department of Energy, Office of Fossil Energy 2001). Forest carbon sequestration refers to the annual rate of storage of carbon dioxide in both aboveground and belowground biomass over the course of a growing season (McPherson and Simpson 1999).

Carbon sequestration depends on tree growth and mortality. Newly planted forests accumulate carbon rapidly for several decades and then sequestration declines as trees mature and growth slows, resulting in less new wood being produced each year. Old forests can release more carbon from decay than they sequester in new growth. It can take several decades or longer for large trees to decay, and old forests generally store considerable amounts of carbon on the forest floor. However, while old forests can maintain a large amount of stored carbon, they reach a point at which they no longer add additional carbon to their stockpile of stored carbon. Harvesting large trees, storing the wood as lumber in buildings, and replanting the area with young, fast-growing trees can add to the stockpile of stored carbon.

4.2.7.1 Affected Environment

Approximately 68 percent of western Washington forested state trust lands are in competitive exclusion and understory development stages. During the sapling and pole exclusion stages, trees begin to compete for space, light, and nutrients; ultimately the taller, faster-growing trees become dominant, causing mortality in the suppressed, smaller trees and creating the first cohort of small snags. Following mortality, decay will cause a release of carbon back to the atmosphere. Additional releases of carbon will come from those trees that are suppressed and ultimately die during the large tree exclusion stage. These larger stems, trees over 20 inches diameter at breast height, have sequestered considerably more carbon than those stems in the sapling and pole exclusion stages. An acre of trees in the sapling and pole stage may accumulate between 5 and 10 tons per acre, while a stand with fewer but larger trees may accumulate carbon at two to three times that rate (McPherson and Simpson 1999). Based on research by Schroeder (1991), thinning of very dense younger stands could increase carbon storage by concentrating growth into crop trees that eventually are used to produce lumber and other products.

Research conducted by Haswell (2000) indicates that lengthening rotation increases the aboveground carbon storage. Extending the rotation age from 40 to 65 years resulted in a 41 percent increase in aboveground carbon storage. Also, larger diameter trees achieved through longer rotation lengths are more likely to produce wood products, such as lumber used in building construction, that will store carbon over long periods of time. The management regime affects the nature of the forest products carbon pool (short rotations tend to produce a higher fraction of short-term products such as paper and cardboard).

4.2.7.2 Environmental Effects Associated with Carbon Sequestration

Estimating the effects of the proposed Alternatives on carbon sequestration is complex. There are many factors that affect sequestration and storage; some components of an Alternative may contribute to a net removal of carbon while some components may offset those gains. Much of the western Washington forested state trust lands support stands in the large stem exclusion and understory re-development stages. Alternatives that propose passive management, Alternatives 1 and 4, would allow much of this area to develop naturally. These stands contain many small trees that will die over the next 2 to 3 decades, allowing the remaining trees to grow and sequester additional carbon. However, the small trees that die will decay over this period, releasing carbon into the atmosphere and offsetting carbon sequestration by living trees, resulting in little or no net gain. Also, these stands have a higher risk of fire because of the heavier fuel loads created by dead and dying trees. If these stands do burn, large amounts carbon would be released. Alternatives that thin these stands (Alternative 5 and the Preferred Alternative), converting a portion of the trees that would likely die into lumber, would increase the net amount of stored carbon because the buildings created with the lumber are likely to last much longer than it would take for these trees to die and decay if left uncut.

Alternatives with longer rotation lengths and intermediate thinnings could increase aboveground carbon storage compared to Alternatives with shorter rotation lengths and no thinnings. Alternatives 1 and 4 are projected to produce more large trees (trees greater than 20 inches diameter at breast height) and, therefore, are likely to store more carbon on site than the other Alternatives. The Preferred Alternative has the next highest distribution of forested acres with large trees, which would likely result in the next highest amount of carbon sequestered and stored on site, followed by Alternatives 2, 3, and 5. However, long-term storage is also affected by the decay of trees and down wood.

While Alternatives 1 and 4 would grow more large trees, they would also harvest less wood than other Alternatives and use less thinning to reduce within-stand competition and tree mortality. More young trees would die and decay, releasing carbon into the atmosphere. Alternatives that concentrate tree growth into crop trees that are harvested and converted to wood products used in buildings would store carbon for longer periods.

In terms of carbon sequestered in lumber and other wood products over the period of analysis, Alternatives 2, 3, 5, and the Preferred Alternative are projected to produce the highest harvest volumes per decade. Much of this volume is projected to be from large trees by the end of the planning period (2067). Harvested trees are likely to be processed into long-term wood products, such as lumber used in building and home construction, and would maintain sequestered carbon well beyond the planning period. Alternatives 4 and 1 are projected to produce the lowest harvested volumes. Alternatives 1 to 4 are likely to store less carbon in the long term than the other Alternatives.

4.2.8 Threatened, Endangered, and Sensitive Plants

4.2.8.1 Affected Environment

The Washington Natural Heritage Program maintains a list of threatened, endangered, and sensitive plant species known to occur in each county. The list is derived from a comprehensive Geographic Information System database of known occurrences of threatened, endangered, and sensitive plants in the state. Appendix D contains a list of threatened, endangered, and sensitive species that either occur or may occur in the general area of forested trust lands. The list is compiled from threatened, endangered, and sensitive species lists for each county that includes western Washington forested state trust lands. The table also includes the habitat requirements for each species and known occurrences of threatened, endangered, and sensitive plants on the forested trust lands.

As shown in Appendix D, many threatened, endangered, and sensitive plant habitats, such as alpine, beach, exposed rock, or exposed grassy bluff, are not likely to be affected by harvest or harvest-related activities. Other habitats such as meadows, prairies, or forest openings may not support trees for harvest but may be adjacent to harvest areas and could potentially be affected by harvest activities. The species that occur in forested habitat, including microhabitats in forests such as forest openings, have a higher likelihood of being affected by harvest or harvest-related activities.

No comprehensive inventory of threatened, endangered, and sensitive plants exists for the forested trust lands. The known occurrence lists do not represent a full inventory. A list of potential species for individual projects can be developed from the Washington Natural Heritage Program database on threatened, endangered, and sensitive species by county.

DNR management activities on all forested trust lands follow Forest Resource Plan Policy No. 23, Endangered, Threatened, and Sensitive Species. The policies and regulations that govern the management of threatened, endangered, and sensitive plants on forested trust lands can be found in Appendix C. DNR's rare plant database is generally reviewed for known occurrences of listed threatened, endangered, and sensitive plants during planning of timber management activities (personal communication with F. Caplow, Washington Natural Heritage Program). There are no DNR procedures requiring review of known occurrences or avoidance of threatened, endangered, and sensitive plants during operations. However, the Habitat Conservation Plan's protection of rare habitats, cliffs, talus slopes, combined with wetland and riparian management measures, provide some incidental protection. The limitations of activities in these areas reduce the likelihood of physically disturbing threatened, endangered, and sensitive plant populations that may exist in these areas.

4.2.8.2 Environmental Effects Related to Threatened, Endangered, and Sensitive Plants

Direct effects to threatened, endangered, and sensitive plants include physical damage or destruction of the plant due to harvest or related activities. Indirect effects include changes in the micro-environment, such as changes in canopy (i.e., available sunlight), changes in hydrology, and increases in competition from weeds or other native species. The range of effects is wide and varied because there are many threatened, endangered, and sensitive plant species with different habitat requirements and life histories. Therefore, each species would potentially have a different sensitivity to particular disturbances. For example, while one species may benefit from additional light due to a reduced canopy cover, another could be negatively affected by direct sunlight.

Comparison of Alternatives

The Alternatives considered in this analysis do not propose any policies or procedures changes related to the management of threatened, endangered, and sensitive plants. The management of these plants is identical under all Alternatives. The difference in effects among the Alternatives would, therefore, be a function of acres of harvest in habitats that may contain threatened, endangered, and sensitive plants. Because the locations of these plant populations are not known, it is assumed that more harvest and harvest-related disturbance has a greater probability of physically disturbing such populations or their habitat. For this analysis, areas that may experience harvest activities and where threatened, endangered, and sensitive plants can occur are considered. These include both riparian and upland areas.

RIPARIAN AREAS

Differences among Alternatives in policies and procedures for managing Riparian Management Zones would affect the amount of harvest within the Riparian Management Zone boundaries. The level of harvest or harvest-related activities in the Riparian Land Class is expected to be related to the potential to disturb or harm a threatened, endangered, and sensitive plant population. More harvest per acre has more potential to physically disturb a plant population. The Preferred Alternative has the highest level of harvest activities, an average of 8 percent of the Riparian Area may be affected based on model results (Table 4.2-15). Therefore, the Preferred Alternative is expected to have the highest probability of affecting threatened, endangered, and sensitive plant populations in riparian or wetland habitats. This is followed by Alternative 5 at approximately 7 percent per decade, Alternatives 3 and 4 at 5 percent per decade, and Alternative 2 at 4 percent per decade. Alternative 1 at 2 percent per decade would have the lowest total harvest in Riparian Areas.

UPLAND AREAS

Diversity of habitats appears to be relatively limited in a fully stocked, young forest (Spies and Franklin 1991), and species diversity is likely to be low. With time, a forest can form a well-developed, multi-layered understory and can become botanically diverse (Carey et al. 1996; Franklin and Spies 1991). A natural consequence of a stand aging is an increase in structural complexity and microsite diversity. Diversity in microsites offers a diversity of habitats and opportunity for species with different habitat requirements to exist. As a stand ages beyond a young forest with a closed canopy, species diversity is expected to increase (Scientia Silvica 1997).

While it is not known whether habitats for specific threatened, endangered, and sensitive plants are developed as harvested areas regenerate, it is expected that as stands develop structural complexity, a more botanically diverse understory would develop, possibly including microhabitats that could potentially support these species. Forest stand development stages that have had sufficient time to develop structural complexity, an understory, and botanically diverse include botanically diverse, niche diversification, and fully functional forest. The effects of harvest on the botanical diversity of these forest stand development stages are discussed in Section 4.2.4.2 of this document and summarized in Table 4.2-8.

The model results show a difference between Alternatives in the acreage that is expected to be in botanically diverse stand development stages by the end of the analysis period (2067). The Preferred Alternative would have the largest portion of forested trust lands (33 percent) in stand development stages with botanically diverse by the year 2067. Therefore, the Preferred Alternative is expected to have developed the largest area with diversity of habitats in forested areas. The Preferred Alternative is followed by Alternatives 1, 2, and 4, with 30 percent, and Alternatives 3 and 5, with 29 percent of acres that would be expected to be in stand development stages with high levels of botanically diverse by the year 2067.

In summary, for riparian habitats, Alternative 1 is expected to have the least potential to affect threatened, endangered, and sensitive plants and the Preferred Alternative would have the greatest potential. However, for forested areas as a whole, the Preferred Alternative would be expected to provide the most acres of diverse habitat to support threatened, endangered, and sensitive plants. In all Alternatives, site-specific analysis would determine the likely effects of individual harvest proposals.

4.3 RIPARIAN AREAS

4.3.1 Summary of Effects

This section analyzes the environmental effects on riparian resources. The analysis examines the current policy and procedures and the future changes proposed to them under the Alternatives. This analysis also allows DNR to assess relative risks that are qualified using modeling outputs.

The distribution of stand development stages within Riparian Areas suggests that, compared to historic unmanaged stands, many moderate to large streams on western Washington forested state trust lands may have reduced levels of multiple riparian functions because of decreased levels of large, fully functioning stands. Riparian areas for smaller streams may have adequate shade and size for potential in-stream large woody debris, but may be deficient in decadent features and other riparian functions important to wildlife and other riparian-dependent species. Many Riparian Areas currently contain moderate to high levels of early stand development stages, and are not likely to change in the near future. Thinning can reduce the time necessary to produce very large trees and reduce the time needed to increase stand complexity.

Removing trees within the Riparian Management Zone may temporarily reduce the level of some riparian functions, but the extent of the reduction depends on where trees are removed, site specific conditions, the amount of trees removed, and the particular riparian function being considered (Washington Forest Practices Board 2001). Such near-term impacts would have to be considered against the potential to accelerate functional recovery. The degree to which moderate intensity timber management would affect near-term riparian function is uncertain. However, active forest management can change species and stand composition and accelerate the development of more complex stand structures (Carey et al. 1996). Such events would help to restore long-term riparian functioning but may have some short-term adverse effects.

Each Alternative proposes different levels of harvest activities in Riparian Areas (Table 4.3-2). During the remaining period of the Habitat Conservation Plan, Alternatives with lower levels of activity, such as Alternatives 1, 2, 3, and 4, are expected to have a higher proportion of Riparian Area with large and very large trees that are in competitive exclusion stages. In contrast, Alternatives with higher levels of active management, such as the Preferred Alternative, are expected to have more Riparian Area that will be fully functioning. (Descriptions of these stand development stages are provided in Appendix B, Section B.2.3.), or be on a trajectory towards full function. Regardless, riparian conditions are expected to improve under all Alternatives relative to current conditions. This is due to changes in stand structure, particularly increases in the amount of stand development stages that include large and very large trees, which are in moderate supply throughout much of the western Washington forested state trust lands (see Figure 4.3-2). The rate of improvement in structurally complex forests overall is similar among most Alternatives, though the Preferred Alternative performs better through 2067. When looking at the two most complex stages of niche diversification and fully functional forests, the Preferred

Alternative accounts for more than 13 percent of Riparian Areas by 2067 compared to about 7 percent for Alternative 1.

4.3.2 Introduction

This section describes the riparian ecosystem and its various functions, the current condition of riparian areas on forested trust lands, the types of allowable activities in Riparian Management Zones, and the likely effects of the Alternatives on the condition of riparian areas. Although riparian areas include in-stream habitat and stream channels, adjacent floodplains, and wetlands (which often include seeps and springs), this section focuses on stream riparian areas. A discussion of riparian buffer protection for wetlands can be found in Section 4.9 (Wetlands).

A wide variety of hydrologic, geomorphic, and biotic processes determine the character of riparian areas. Riparian areas have distinctive resource values and characteristics that make them important zones of interaction between terrestrial and aquatic ecosystems.

On forested trust lands, riparian functions are protected through the use of Riparian Management Zones, where the amount and type of management activities that can be implemented are restricted to meet the Habitat Conservation Plan's conservation objectives. During the scoping for this Environmental Impact Statement, the amount of activity in Riparian Management Zones was identified as an important issue, particularly concerning activities for restoration of targeted riparian functions.

4.3.3 Affected Environment

This section provides a short discussion of riparian functions. It also discusses the current condition of riparian areas on forested trust lands.

4.3.3.1 Riparian Functions

The most important recognized functions of stream riparian areas include large woody debris recruitment, leaf and needle litter recruitment, stream shade, microclimate, streambank stability, and sediment control. To understand the impacts of various management actions, it is important to understand these functions. Many authors have reviewed these functions (e.g., Murphy and Meehan 1991; Forest Ecosystem Management Assessment Team 1993; Spence et al. 1996; DNR 1996 [pages IV-145 to IV-175]; Washington Forest Practices Board 2001 [pages 3-36 to 3-40]), and their work provides the basis for this analysis.

Large Woody Debris Recruitment

Large woody debris includes entire trees, rootwads, stems, and larger branches. The Washington Forest Practices Board (1995) defines large woody debris as pieces greater than 4 inches in diameter and more than 6.5 feet in length. Riparian areas are an important source of large woody debris that can be recruited to the stream channel. Large woody debris recruitment originates from a variety of processes, including tree mortality (toppling), windthrow, undercutting of streambanks, debris avalanches, deep-seated mass soil movements, and redistribution from upstream (Swanson and Lienkamper 1978). The loss of large woody debris results from breakage, decomposition, and redistribution downstream.

Numerous studies have shown that large woody debris is an important component of fish habitat (Swanson et al. 1976; Bisson et al. 1987; Naiman et al. 1992) and that it is critical for sediment retention (Keller and Swanson 1979; Sedell et al. 1988), gradient modification, structural diversity (Ralph et al. 1994), nutrient production and retention (Cummins 1974), and protective cover from predators.

There is a strong relationship between channel width and the size (diameter, length, and volume) of large woody debris that forms a pool, an important component to fish habitat (Bilby and Ward 1989). Large woody debris that is large enough to form a pool is referred to as "functional large woody debris," and can have a minimum size of about 12 inches in diameter in small streams (Bilby and Ward 1989). Even larger woody debris that is also effective in trapping smaller more mobile pieces of large woody debris (i.e., forming logjams), and more likely to have long-term stability is sometimes referred to as "key piece large woody debris." Key piece large woody debris is considered by some to be a better measure of the important wood recruitment sizes with a minimum size of 16.5 inches in diameter for small streams (Washington Forest Practices Board 1995).

The relationship between large woody debris size and function needs to be evaluated when considering activities in buffer strips. Riparian Management Zones need to ensure not only an appropriate amount or volume of wood, but wood of sufficient size to serve as both functional and key pieces (Murphy 1995). Consequently, the size distribution and type of trees present in the riparian zone are important factors for maintaining adequate large woody debris recruitment. Measurable contributions of wood from second-growth riparian areas are documented to take anywhere from 60 to 250 or more years, depending on region and size of stream (Grette 1985; Bilby and Wasserman 1989; Murphy and Koski 1989). Conifers tend to have a larger potential maximum size and decompose more slowly than hardwoods, but they also tend to grow more slowly, particularly in unmanaged conditions, than most western Washington hardwoods.

Leaf and Needle Litter Production

In aquatic systems, some vegetative organic materials (such as algae) originate within the stream while others (such as leaf and needle litter) originate from sources outside the stream. Stream benthic communities (e.g., aquatic insects) are highly dependent on materials from both sources. The abundance and diversity of aquatic species can vary significantly depending upon the total and relative amounts of algae, leaf, and litter inputs to a stream (IMST 1999).

Most of the vegetative organic debris input into small- and medium-sized streams comes from outside the stream, through the annual contribution of large amounts of needles, leaves, cones, wood, and dissolved organic matter (Gregory et al. 1991; Richardson 1992). In contrast, wide high-order (larger) streams with higher levels of direct sunlight, or low-order (smaller) streams with an open riparian canopy also rely on in-stream processes such as algae production for organic material input. The source and level of organic debris input can change in a riparian stand. For example, as a riparian stand ages, the amount of litter-fall increases (IMST 1999).

The importance of leaf and needle litter input varies among streams, but it can provide up to 60 percent of the total energy input into stream communities (Richardson 1992). Litter deposited into small, steep-gradient streams in forested areas high in a watershed is generally transported downstream, because higher gradient streams are less likely to retain deposited organic material until it has decomposed. Therefore, small (low-order) streams are important sources of nutrients and contribute substantially to the productivity of larger streams in the lower reaches of a watershed (IMST 1999).

Stream Shade

Stream temperature is an important factor affecting the types of aquatic life that can live in a stream, and all aquatic organisms have a temperature range outside of which they cannot exist. Stream temperature also influences water chemistry, which can affect the amount of oxygen present to support aquatic life. Stream shade is an important factor affecting stream temperature. Several factors control the heat balance of water in streams, including air temperature, solar radiation, evaporation, convection, conduction, and advection (Brown 1983; Adams and Sullivan 1990). Stream temperatures have a natural tendency to warm from the headwaters of a stream to the ocean (Sullivan et al. 1990; Zwieniecki and Newton 1999). However, seasonal and daily cycles produce a high degree of variability in-stream temperature.

Summertime temperatures are of particular interest in western Washington. During the summer, when stream temperatures are the highest, the major factors affecting stream temperature are warmer air temperatures, increased direct solar radiation, and decreased stream flows (Beschta et al. 1987). Forest management activities can have the greatest effect on direct solar radiation by reducing or promoting shade. Shade cannot physically cool a stream down, but it can prevent further solar heating and thus maintain the water temperature from groundwater inputs or tributaries. Shade provided by riparian vegetation has been shown to be successful in minimizing or eliminating increases in-stream temperature associated with timber harvest (Brazier and Brown 1973; Lynch et al. 1985). Other factors that affect shading include stream size and stream orientation, local topography, tree species, stand age, and stand density.

Microclimate

Microclimates tend to vary greatly across the landscape. Each microclimate is a collection of variables that are highly dependent on local conditions. Important components of microclimate include solar radiation, soil temperature, soil moisture, air temperature, wind velocity, and air moisture or humidity (reviewed in Spence et al. 1996; Forest Ecosystem Management Assessment Team 1993).

Removing streamside vegetation may result in changes in microclimatic conditions within the riparian zone. These changes can influence a variety of ecological processes that may affect the long-term integrity of riparian ecosystems (Spence et al. 1996). For example, many of the variables considered in microclimate studies (air temperature, humidity, wind velocity) are also variables that affect water temperature (Sullivan et al. 1990).

Microclimate is also important to stream/riparian species other than fish, such as amphibians.

In general, due to their low-lying position on the landscape, riparian areas tend to be cooler than the surrounding hillslopes, especially during the night. Because riparian areas are adjacent to water bodies, they often have a higher relative humidity under the canopy than similar upslope areas. This increase in humidity combined with shading effects can cause intact forested riparian areas to have a moderating effect on microclimate (Beschta and Boyle 1995).

Sediment Control and Streambank Stability

The delivery of fine and coarse sediment to streams can lead to stream channel instability, pool filling by coarse sediment, creation of spawning gravels, or introduction of fine sediment to spawning gravels. Sediment can be delivered to the aquatic system as surface erosion (mostly fine sediment) generated from harvest units, skid trails, and roads or stream crossings within the riparian area. It can also be delivered as landslides or debris torrents (coarse and fine sediments), whether initiated naturally or in harvested areas on unstable slopes. Additional discussion of surface erosion and landslides is provided in Section 4.6, Geomorphology, Soils, and Sediment.

Timber harvest activities can alter watershed conditions by changing both quantity and size distribution of sediment delivery to streams. Streamside buffer strips can significantly reduce the amount of coarse sediment that reaches a stream, by filtering it through the vegetation. Similarly, buffer strips can limit the amount of fine sediment that reaches a stream from surface erosion by physically obstructing or inhibiting the movement of the sediment into the water. The ability of riparian buffer strips to control sediment inputs in this manner depends on several site characteristics, including the presence of vegetation or organic litter, slope, soil type, and drainage characteristics.

Landslides are important to riparian areas as a natural disturbance mechanism and are episodic sources of large woody debris, as well as fine and coarse sediment in streams. They are part of the natural processes that create and/or maintain riparian functions. Debris slides are the most common landslides on steep forestlands. More intense types of slides include debris torrents and debris flows, which may follow existing stream channels. Major storms can increase the rate and intensity of landslides. Sidle et al. (1985) summarized several studies indicating that slope stability depends partly on reinforcement from tree roots, especially when soils are partly or completely saturated. In addition to having significant impacts on the stream channel, debris torrents can also affect riparian buffer functions and streamside forests when bank scour removes streamside vegetation.

The stability of streambanks is largely determined by the size, type, and cohesion of the soil profile; vegetation cover; root mass; and the amount of bedload carried by the channel (Sullivan et al. 1987). Riparian vegetation can provide hydraulic roughness that dissipates stream energy during high or overbank flows, which further reduces bank erosion. In most cases, vegetation immediately adjacent to a stream channel is most important in maintaining bank integrity (Forest Ecosystem Management Assessment Team 1993).

However, in wide valleys with shifting stream channels, vegetation throughout the floodplain or channel migration zone may also be important over longer time periods.

4.3.3.2 Current Management Direction

Procedures 14-004-150 (five Westside HCP Planning Units) and 14-004-160 (the Olympic Experimental State Forest HCP Planning Unit) for Identifying and Protecting Riparian and Wetland Management Zones have been developed to implement the Forest Resource Plan policy and Habitat Conservation Plan (HCP) conservation strategy. Currently, the Riparian Conservation Strategy for the HCP has not been completely implemented. Procedure 14-004-150 is interim until the permanent procedure is developed and approved by the Federal Services. A permanent strategy is currently under development and review by DNR and Federal Services staff (Washington DNR 2004). Under the current interim procedure, timber harvest is not allowed within Riparian Management Zones except for yarding corridors, road-stream crossings, and road-building. Other management activities can only occur with specific approval by the State Lands Assistant. Additional details concerning DNR riparian policies and Procedures 14-004-150 and 14-004-160 can be found in Appendix C.

4.3.3.3 Current Riparian Conditions

As described in Section 4.2 (Forest Structure and Vegetation), stand developmental stages can be a useful measure for describing forest structural conditions, including those found in riparian stands. Figure 4.3-1 and Table 4.3-1 depict the distribution of stand development stages in the Riparian land class for the five westside HCP Planning Units and the Olympic Experimental State Forest. The Riparian land class includes stream and wetland riparian buffers plus their associated wind buffers. Under the Habitat Conservation Plan some locations require wind buffers; for the purpose of uniform analysis, wind buffers are assumed to be required. The stand development stages are described in detail in Appendix B.

Historically, Pacific Northwest forests (including riparian areas) were a mosaic of different forest types and ages. Large areas of “old growth” forest were common (Franklin et al. 1981), which is interpreted in this EIS to mean forest stands in the fully functioning stand development stage. However, compared to upland forests, riparian areas are more frequently disturbed by fluvial processes and can have more diverse stands than upland areas (Agee 1988). The National Marine Fisheries Service (1996) considers watersheds with riparian areas at least 50 percent similar to the “potential natural community” as being “properly functioning.” Those between 25 to 50 percent similar are considered “at-risk,” and those with less than 25 percent are considered “not properly functioning.” Such ratings tend to be relative, not absolute. There is also substantial variability in what constitutes a natural community, depending upon the nature and distribution of the riparian communities within a given stream reach and the localized disturbance history.

As described in Section 4.2 (Forest Structure and Vegetation), stand developmental stages can be a useful measure for describing forest structural conditions, including those found in riparian stands. Figure 4.3-1 and Table 4.3-1 depict the distribution of stand development stages in the Riparian land class for the five Westside HCP Planning Units and the

Olympic Experimental State Forest. The Riparian land class includes stream and wetland riparian buffers plus their associated wind buffers. Under the Habitat Conservation Plan, some locations require wind buffers; for the purpose of uniform analysis, wind buffers are assumed to be required. The stand development stages are described in detail in Appendix B.

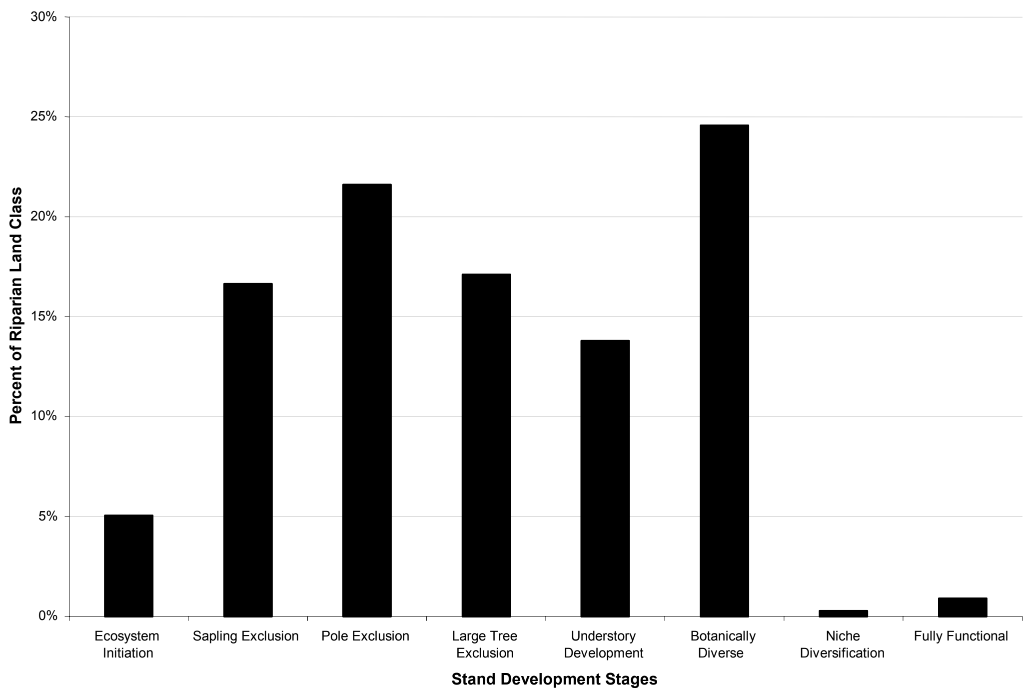

Figure 4.3-1. Distribution of Stand Development Stages within the Riparian Land Class on DNR Forested Trust Lands

Data Source: Model output data – stand development stages

Table 4.3-1. Distribution of Stand Development Stages within Riparian Areas[1/] Among the Five Westside HCP Planning Units and the Olympic Experimental State Forest

Stand Development Stage	North Puget	South Puget	Columbia	South Coast	Olympic Experimental State Forest	Straits	Total
Ecosystem Initiation	5.4%	5.1%	4.7%	4.8%	5.3%	4.9%	5.0%
Sapling Exclusion	14.6%	14.7%	12.4%	13.7%	25.0%	13.6%	16.6%
Pole Exclusion	16.4%	22.2%	22.3%	16.4%	29.6%	18.3%	21.6%
Large Tree Exclusion	15.5%	14.3%	26.6%	26.8%	5.5%	14.0%	17.1%
Understory Development	18.1%	15.5%	11.5%	19.1%	6.3%	20.7%	13.8%
Botanically Diverse	27.9%	28.1%	21.6%	19.1%	26.3%	28.3%	24.6%
Niche Diversification	0.2%	0.1%	0.1%	0.0%	0.7%	0.1%	0.3%
Fully Functional	1.8%	0.0%	0.9%	0.1%	1.3%	0.0%	0.9%
Total Stream-Associated Riparian Acres[2/]	**78,143**	**28,509**	**78,202**	**72,893**	**61,497**	**16,064**	**335,308**
Total Riparian Land Class Acres[3/]	**92,724**	**34,606**	**86,443**	**80,966**	**111,308**	**20,684**	**426,731**

Data Source: Model output data – stand development stages.
1/ Percentages based upon the total Riparian land class acreage, which include modeled buffers for riparian areas adjacent to types 1-4 streams and wetlands plus associated wind buffers. Definitions are based on Carey et al. 1996.
2/ Acreage does not include wetland and wind buffer areas.
3/ The Riparian land class includes stream-associated riparian areas, wetland areas, and wind buffer areas.

In general, riparian areas within the five Westside HCP Planning Unit and the Olympic Experimental State Forest are currently dominated by the competitive exclusion developmental stages (sapling, pole, and large tree), but also have a large component within the botanically diverse developmental stage. Within the five Westside HCP Planning Units and the Olympic Experimental State Forest, 46 to 61 percent of the Riparian land class on forested trust lands consists of single-canopy forest, including sapling, pole, and large tree exclusion stages (Table 4.3-1 and Figure 4.3-1). Multi-layered stands occur on about 34 to 49 percent of the Riparian land class in the five Westside HCP Planning Units and the Olympic Experimental State Forest, including understory development, botanically diverse, niche diversification, and fully functional stages. Notably, the amount of the fully functional stage, which is most prevalent in pristine riparian areas, is less than one percent of the Riparian land class.

Two ranges of tree sizes are of particular importance for riparian areas: large and very large trees. Within the large tree exclusion and understory development stages, dominant trees are 20 to 29 inches in diameter at breast height, but a few very large trees (greater than 30 inches diameter at breast height) may be present. Under the large tree exclusion stage, stands have a single canopy and closure is greater than 70 percent. The understory development stage represents the transition between single and multi-canopy forest and generally has a larger proportion of very large trees, as well as poles and saplings, which each may make up 10at least five percent or more of these stands, although pole and sapling densities are low except in canopy gaps, which results in canopy closure levels of less than 70 percent.

Dominant trees in these stand development stages are sufficiently large to provide functional large woody debris and shade to streams of moderate or smaller size (up to about 60 feet in width), based upon a relationship observed by Bilby and Ward (1989). Approximately 31 percent of the Riparian land class on forested trust lands are in stand development stages containing large trees with a range of 12 (Olympic Experimental State Forest) to 46 (South Coast) percent among the different HCP Planning Units.

The botanical diversity, niche diversification, and fully functional stand development stages contain “very large” trees (more than 30 inches diameter at breast height). Very large trees are needed to supply large woody debris and shade to larger streams and rivers or are needed in the outer portions of the Riparian Management Zones. At increasing distances from a stream, a tree must be larger and taller to effectively supply large woody debris to a stream (McDade et al. 1990). A similar relationship occurs for providing shade. The Riparian land class in the HCP Planning Units range from approximately 19 (South Coast) to 30 (North Puget) percent in the botanically diverse, niche diversification, and fully functional stand development stages with an average of about 26 percent for all HCP Planning Units. Stands containing very large trees are present at moderate levels on forested trust lands in most western Washington watersheds. However, nearly all of the stands containing very large trees are in the botanically diverse development stage. Only about 1 percent of the Riparian land class is in the niche diversification and fully functional development stages, which are stages that have a high level of decadence.

Approximately 22 percent of riparian stands in the forested trust lands consist of single-canopy forest in the ecosystem initiation and sapling exclusion stages, which include trees 0 to 9 inches in diameter at breast height. Approximately 30 percent of the riparian stands in the Olympic Experimental State Forest are in these early development stages.

An evaluation of the data for DNR-managed forested trust lands by watershed indicates that approximately 11 percent of the watersheds have Riparian land class areas that are mostly in the ecosystem initiation and sapling exclusion stages, and approximately 37 percent of the watersheds have at least one-quarter of the Riparian land class area in these early development stages. These levels suggest that a substantial amount of riparian area was disturbed prior to the implementation of the Habitat Conservation Plan (DNR 1997), primarily from timber harvest.

In conclusion, the distribution of stand development stages within riparian areas suggests that many moderate to large streams on forested trust lands may have reduced levels of one or more riparian functions under current conditions because of low to moderate levels of large, fully functioning stands; whereas, under historical unmanaged conditions, high levels of these stand types were the norm. These areas are likely to remain in this status for the near future because they contain moderate to high levels of early stand development stages. In contrast, many small to moderately sized streams may be approaching a moderate to high level for some riparian functions, such as potential functional in-stream large woody debris and shade from trees in intermediate development stages, but may have substantial reductions in other riparian functions and lack decadent features important for some wildlife and riparian-dependant species. Overall, riparian areas have a relatively high proportion of early and mid-developmental stages and low proportions of older developmental stages of forest, with a more structurally complex stand structure.

4.3.4 Environmental Effects

The following provides an overview of the general effects of forest management on riparian functions. More details of these general effects can also be found in the Habitat Conservation Plan Environmental Impact Statement (DNR 1996) and the Forest and Fish EIS (Washington Forest Practices Board 2001). The potential effects of the Alternatives are discussed.

4.3.4.1 Forest Management in Riparian Zones

Forest management activities, including road-building and stream crossings, yarding corridors, restoration, vegetation management (both herbicide and fertilization use), and varying levels of timber harvest, will change the forest structure within the riparian areas. The potential for adverse effects to riparian and aquatic functions have been extensively documented (e.g., Meehan 1991; Salo and Cundy 1987). Over the past quarter century, management prescriptions for the restriction and mitigation of forest management in and near riparian zones have been developed to avoid or minimize the potential for adverse effects. Furthermore, forest managers are now developing and implementing techniques to enhance and restore riparian zone functions.

Development of permanent roads removes trees within the road corridor, disturbs streambanks, and may provide a pathway for the transport of water and sediment from the roadway to a stream. Yarding corridors also remove trees, and may contribute to high levels of soil disturbance or compaction along yarding corridors if adequate suspension of logs is not achieved or appropriate mitigation measures are not implemented to reduce adverse effects. Yarding corridors are generally used when cross-stream yarding is more economical and less damaging to the environment than building a road. Maintenance and re-growth of brushy vegetation and trees reduce the risk of adverse effects. Protection of streambank integrity and adequate soil filtering of surface erosion are generally maintained with a fully functioning stand within 30 feet of a stream (Washington Forest Practices Board 2001).

Active timber management in the form of patch cuts and upland regeneration harvests can also affect the risk of windthrow in riparian buffers. Data for windthrow within riparian buffers from seven studies reported in Grizzel and Wolff (1998) had a mean windthrow rate (i.e., proportion of riparian buffer trees to blow down) of about 15 percent for 344 sites in western Washington and Oregon, with maximum windthrow rates ranging from 17 to 100 percent in the different studies. Pollock and Kennard (1998) re-analyzed several windthrow data sets looking at the relationship between buffer width and likelihood of windthrow. They reached the conclusion that buffers of less than 75 feet have a higher probability of suffering appreciable mortality from windthrow than forests with wider buffers. In general, vulnerability to windthrow tends to return to normal a few years after logging (Moore 1977; Steinblums 1978; Andrus and Froelich 1986).

Patch cuts may be used as a commercial activity in upland areas or the outer portions of Riparian Management Zones. This technique may also be implemented within riparian areas as a restoration activity to convert hardwood to conifer stands and as a tool for biodiversity pathways management. Huggard and Vyse (2002) recommended that variable patch cuts less than 2.5 acres in size for enhancing ecological diversity, and also found that windthrow risk declines with patches smaller than that size. Carey et al. (1996) recommended management patches on the order of 0.5 to 1.0 acre in size to mimic natural patterns.

The effects of partial harvest techniques such as variable size patch cuts, single tree selection, and variable density thinning are not fully understood. Non-linear curves depicting the relationship between riparian function and distance from the stream (Washington Forest Practices Board 2001, pages 3-48 and 3-49) are generally based upon fully developed stands (i.e., the fully functioning stand development stage). They suggest that most riparian functions are fully protected within one site potential tree height, a distance equal to the anticipated tree height for the specific site. Because the classification of the stand development stages was based upon generic forest stand characteristics rather than riparian function, the fully functioning stand developmental stage represents fully functioning forest stand structure rather than specific riparian function. Riparian stands need to be not only in the fully functioning stand development stage, but also need to be sufficiently wide to achieve a high level of protection for riparian functions.

Removing trees within the Riparian Management Zone may temporarily reduce the level of the riparian functions described above, but the extent and duration of the reduction depends on where trees are removed, site-specific conditions, the amount of trees removed, and the particular riparian function being considered (Washington Forest Practices Board 2001). The duration of the recovery period can also depend upon the type and amount of mitigation applied during and after harvest activities. Such near-term impacts would have to be evaluated considered against the potential to accelerate functional recovery.

Based upon recent evaluations of riparian function (Washington Forest Practices Board 2001), a complex, multi-storied stand with decadence features and very large trees (i.e., the fully functional stand development stage) within a buffer 0.75 of a site potential tree height in width along a stream (approximately 105 feet for Douglas-fir on site class III soils) would provide complete shade protection and about 90 percent of large woody debris recruitment (Washington Forest Practices Board 2001). Removal of some trees from this hypothetical stand between 75 and 100 feet from the stream would likely reduce some amount and types of large woody debris recruitment, but would have minimal effect on shade. The conversion of hardwood areas in patches greater than about 0.25 acre may result in a higher risk of windthrow (Huggard and Vyse 2002), which could increase the amount of downed wood and in-stream large woody debris, but decrease the standing crop available for future recruitment. However, it is worth noting that many riparian stands are not fully functioning because of their current structural condition and species composition.

The degree to which moderate intensity timber management would affect near-term riparian function is uncertain because few empirical studies have been completed. However, active forest management can change species and stand composition and the number and distribution of larger trees, and accelerate the development of larger trees and more complex stand structures (Carey et al. 1996). Such activities help to restore longer-term riparian functioning but may have some short-term adverse effects.

A riparian stand may not be fully functioning because of current site conditions; previous management activities; or disturbance from fluvial processes, disease, or fire. Carey et al. (1996) proposed that active management of forest stands on a biodiversity pathway using Alternative silvicultural practices can result in full stand function being achieved more rapidly. These Alternative practices may include:

- pre-commercial and modified commercial thinning to stimulate tree growth and understory development;
- planting to supplement natural regeneration;
- retention of large legacy trees; and
- recruitment of down woody debris to terrestrial and aquatic systems and creation of large snags.

The riparian management strategies examined under the Alternatives are described in Chapter 2. Other policies and procedures that affect riparian conditions are described in Appendix C. Each Alternative proposes different levels of harvest activities in riparian areas (Table 4.3-2). During the remaining period of the Habitat Conservation Plan, Alternatives with lower levels of activity, such as Alternatives 1 through 4, are expected to have a higher proportion of riparian area with large and very large trees that are in competitive exclusion stages. In contrast, Alternatives with higher levels of active management, such as the Preferred Alternative, are expected to have more riparian area that will be fully functioning, or be on a trajectory towards full function. Regardless, riparian conditions are expected to improve under all Alternatives relative to current conditions. This is due to changes in stand structure, particularly increases in the amount of stand development stages that include large and very large trees, which are in moderate supply throughout much of the western Washington forested state trust lands (see Figure 4.3-2). The rate of improvement in structurally complex forests overall is similar among the Alternatives. However, active management under the Preferred Alternative is expected to achieve fully functioning stands within 80 to 90 years, rather than approximately 220 years using passive techniques (Carey et al. 1996). Larger and taller trees combined with a complex canopy structure in the riparian zone have a greater likelihood of providing streams with more functional large woody debris, more shade, more leaf and needle litter, and improved microclimate conditions.

Table 4.3-2. Estimated Acres of Forest Management in the Riparian Land Class per Decade among the HCP Planning Units for Each Alternative

	Period	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	PA
Olympic Experimental State Forest (110,000 total acres in Riparian land class)	2004-2013	1,391	3,636	1,979	1,325	8,519	5,169
	2014-2023	1,436	4,440	2,124	1,393	13,360	3,882
	2024-2033	1,949	5,498	5,231	1,634	16,198	6,270
	2034-2043	1,693	6,591	5,917	1,788	14,068	5,435
	2044-2053	1,328	5,786	9,877	1,682	7,773	6,925
	2054-2063	1,637	6,898	7,668	1,668	3,486	9,292
	2064-2067	612	2,335	4,614	818	643	2,807
	Mean	**1,570**	**5,498**	**5,845**	**1,611**	**10,007**	**6,216**
Five Westside Planning Units (excludes OESF; 315,000 total acres in Riparian land class)	2004-2013	5,714	10,798	11,568	14,061	17,957	14,010
	2014-2023	7,902	13,144	17,414	13,637	25,922	39,779
	2024-2033	9,791	15,781	17,300	16,717	35,545	24,130
	2034-2043	7,321	13,118	15,688	18,871	17,531	22,860
	2044-2053	7,150	14,615	16,782	20,884	15,453	29,955
	2054-2063	7,582	14,055	11,489	24,997	15,448	25,725
	2064-2067	2,652	3,897	4,238	9,563	4,511	13,714
	Mean	**7,518**	**13,345**	**14,763**	**18,552**	**20,683**	**26,589**

Data Source: Model output data – timber flow levels.
OESF = Olympic Experimental State Forest
PA = Preferred Alternative

Model results suggest a variety of thinning activities, some of which remove up to 50 percent of the basal area of a stand, are needed to speed the development of stands in large tree exclusion stages and to structurally complex and fully functioning stands. The Preferred Alternative addresses this need through infrequent, relatively heavy thinning activities. This may occasionally take the form of one pre-commercial thinning when the stand is in the sapling exclusion stage, but more typically may include one commercial thinning when the stand is in the pole or large tree exclusion stage. Commercial thinning is likely to be done in conjunction with an upland harvest activity.

Over the short term (i.e., the next decade of the Habitat Conservation Plan), little difference is expected in the distribution of stand development stages among the six Alternatives (Figure 4.3-2). The proportion of Riparian land class in stand development stages, including large and very large trees development stages, is expected to increase from about 57 to 62 or 63 percent. Nearly all of this increase is expected in the large tree exclusion and understory development stages. The amount of very large trees is expected to remain at about 25 to 26 percent of the Riparian land class because increased growth expected from stand manipulations would take some time to become fully expressed, and only a small percentage of riparian areas would be treated in the first decade (up to about 4.5 percent of the riparian area).

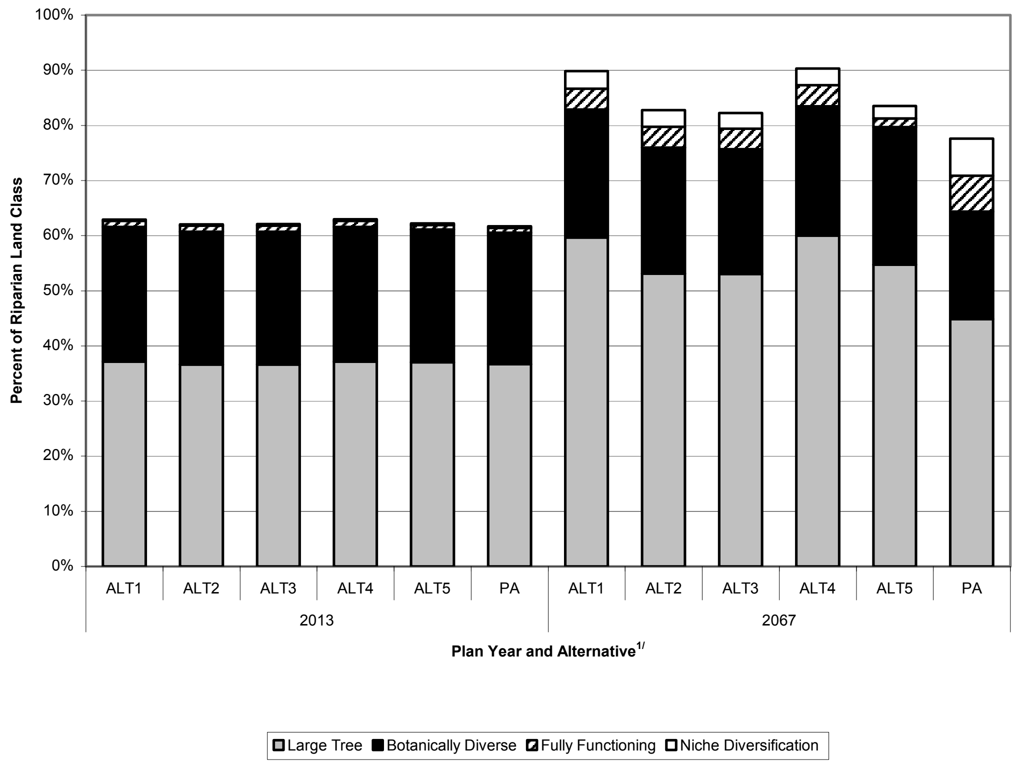

Figure 4.3-2. Percent of the Riparian Land Class that is in Large Tree and Very Large Tree Stand Development Stages[2/] in the Short Term and Long Term

Notes:

1/ Under current conditions, the proportion of the Riparian land class containing large and very large trees is estimated to be approximately 57% of 426,000 acres.

2/ "Large trees" include the large tree exclusion and understory development stages, and "very large trees" include the botanically diverse, niche diversification, and fully functional development stages.

PA = Preferred Alternative

Source: DNR model output data – stand development stages

Differences among the Alternatives are expected to become more substantive over the long term (Figure 4.3-2). The proportion of the Riparian land class with stand development stages containing large tree and very large trees is expected to increase over current conditions from about 57 percent to 78 to 90 percent, depending upon the Alternative. Consequently, the large woody debris recruitment, leaf and needle litter production, and shade conditions would be expected to improve under all Alternatives. Alternatives 1 and 4 are expected to have the highest amount, with about 90 percent of the Riparian land class in these stages. Alternatives 2, 3, and 5 are expected to be intermediate, at about 82 to 83 percent. The Preferred Alternative is expected to have the lowest proportion of the Alternatives, with about 78 percent of the Riparian land class in stand development stages containing large and very large trees.

The modeling results support the qualitative assessment that under the Preferred Alternative, active management of stands in competitive exclusion stages helps to move stands towards development pathways that more rapidly lead to a fully functional, complex stand structural state. Although the Preferred Alternative is expected to have the lowest proportion of stand development stages containing large and very large trees, it is also expected to have the highest proportion of the most complex classes of niche diversification and fully functioning stand development stages. These two complex stages are each expected to comprise about 6 to 7 percent of the Riparian land class. In contrast, Alternatives 1 to 4 are expected to have about 4 percent and 3 percent of the Riparian land class in niche diversification and fully functioning stages, respectively, while Alternative 5 is expected to have about 2 percent in each. The major added feature that distinguishes the fully functional and niche diversification development stages from other multi-canopy stages with very large trees is the presence of higher levels of decadence, such as snags, down coarse woody debris, and epiphytes. Under the Preferred Alternative, the trend towards the increased development of these complex multi-story stands in treated areas is expected to continue after completion of the Habitat Conservation Plan, assuming the conservation strategy is also continued. Under all Alternatives, areas with large and very large trees in competitive exclusion stages would likely achieve full function eventually over time. However, given stand densities within riparian areas and the level of natural or managed disturbance needed for succession through the development stages, Alternatives 1 to 5 may require a very long time to produce substantial amounts of fully functioning riparian forests.

Over the long term, the more intensive biodiversity pathways approach proposed in the Preferred Alternative is expected to yield higher riparian function on more of the Riparian land class than Alternatives 1 to 5, but with the short-term trade-off of having potentially less area with large trees in the Riparian land class. The Preferred Alternative is also expected to have the highest proportion (about 22 percent) in the small tree (saplings and poles) and ecosystem initiation stages over the long term compared to Alternatives 1 through 5, which are expected to have a range of about 10 to 18 percent of the Riparian land class in these stand development stages.

The Habitat Conservation Plan (HCP) was written with specific direction for riparian protection, but was more flexible concerning riparian enhancement activities. The activity levels in the riparian zone for the first decade under all Alternatives (Appendix D) are expected to be within the levels expected for the first decade under the HCP, about 23,000 acres for the five Westside HCP Planning Units and 10,000 acres for the Olympic Experimental State Forest (DNR 1997, IV. 212). Pre-commercial thinning, commercial thinning, partial cuts, single tree selection, and stand conversion were all considered appropriate activities that could be used to maintain or restore riparian functions (DNR 1997, IV. 208). In addition, in their Biological Opinions on the HCP, the Federal Services assumed that a long-term average of about 1 percent of riparian areas available to commercial activities would be harvested on an annual basis, or about once over a 100-year period. This equates to about 10 percent per decade.

Over the seven decades modeled, all of the Alternatives had a long-term average of less than 10 percent of the Riparian land class per decade for both enhancement and commercial activities (Appendix D, Tables D-5a to D-5f). Activity levels ranged from an average of about 2 to 8 percent of the Riparian land class per decade, with Alternative 1 at the lowest level and the Preferred Alternative at the highest level. Consequently, all of the Alternatives are considered to be within the range expected under the HCP because these activities would be less than a long-term average of 10 percent per decade. In addition to the Alternative riparian management intensity, the amount of activity within any given HCP Planning Unit or decade varied in the models because stand conditions, and consequently enhancement or commercial opportunities, vary with time.

Compared to Alternative 1 (No Action), which has a long-term average activity level of about 2 percent per decade, and a maximum HCP Planning Unit/decadal activity level of 4 percent, the Preferred Alternative is expected to have a higher potential risk of adverse effects in some HCP Planning Units and decades. This increase in risk is considered to be low to moderate if mitigation measures (discussed below) are implemented and are effective. The risk of adverse effects under Alternatives 2, 3, and 4, with long-term average activity levels of about 4 to 5 percent and maximum HCP Planning Unit/decadal activity level of about 8 to 11 percent, is only slightly higher than under Alternative 1. Alternative 5, with a long-term average activity level of about 7 percent and maximum HCP Planning Unit/decadal activity level of about 15 percent (Olympic Experimental State Forest Decade 32024 to 2033), has a slightly lower risk than the Preferred Alternative (8 percent).

Modeled activity levels under the Preferred Alternative range up to nearly 20 percent of the Riparian land class in some HCP Planning Units and decades, but overall have a long-term decade average of 8 percent. Individual HCP Planning Units have a long-term average of 6 percent (Olympic Experimental State Forest) to 11 percent (South Coast and Straits). The years 2014 to 2023 are expected to have the highest level of riparian activities, with an average of about 10 percent. Activities in the Columbia (about 16 percent), South Coast (about 14 percent), and Straits (about 20 percent) HCP Planning Units are expected to incur the bulk of the activities during that decade.

Large woody debris recruitment, leaf and needle litter production, and shade conditions would be expected to improve under all Alternatives relative to current conditions. However, relative to Alternative 1, some short-term reduction in leaf and needle litter production and long-term reduction in shade and large woody debris potential may occur from the removal of riparian trees. Generally, this impact would be expected to be relatively minor. Under the Preferred Alternative, localized reductions in leaf and needle litter, shade, and large woody debris recruitment potential could occur in some HCP Planning Units during some decades, but these adverse effects are expected to transition into long-term beneficial effects in the form of more structurally diverse riparian forest. These potential adverse effects would likely be more pronounced in areas where tree removal occurs in the minimal harvest sub-zone. Larger patch cuts could result in a higher risk of windthrow for some riparian trees that would contribute to in-stream and terrestrial down wood levels. Although restoration activities are allowable within all riparian buffer areas under the Habitat Conservation Plan, none of the Alternatives proposes activities within the 25-foot no-harvest buffer along types 1 through 4 streams within the five Westside HCP Planning Units (excluding the Olympic Experimental State Forest), except for yarding corridors, roads, and restoration activities.

The Preferred Alternative is expected to mitigate the localized reductions in large woody debris potential by active development of down woody debris and in-stream large woody debris through the felling of large trees and leaving them in place. The draft riparian strategy currently under development by DNR and the Federal Services includes this technique in locations where these features are lacking (DNR 2004). This active management technique would provide immediate improvements in the availability of these features at places where treatments are implemented. In contrast, Alternatives 1 to 5 would require relatively infrequent natural disturbances (e.g., windthrow, fire, disease, decadence, etc.) to increase downed wood and large woody debris levels.

Ground-based and cable yarding methods could result in low levels of soil compaction and/or rutting and surface erosion along skid trails in the riparian zone. Given the nature of the requirements of the Forest Practices Rules, the Habitat Conservation Plan, and the Riparian Forest Restoration Strategy (DNR 2004), no Alternative is likely to cause substantial adverse effects on streambank stability or sediment filtering capacity. The site-specific assessment of conditions required under Procedure 14-004-160 is expected to identify and avoid or minimize potential streambank stability or sediment-filtering effects within the Olympic Experimental State Forest.

The relative impact to riparian microclimate among the Alternatives is uncertain. Riparian microclimate conditions would likely improve under all Alternatives as the amount of area in stand development stages with small trees declines with time, and the amount of area in development stages with multiple canopies and very large trees increases. The effects of patch cuts, small openings, and thinnings on riparian microclimate are largely unknown. If differences were to occur among the Alternatives, the level and type of riparian disturbance would be the best relative indicator available, with the Preferred Alternative and Alternative 5 having the highest likelihood of expressing any relative difference and Alternatives 1 and 4 having the lowest.

Harvest prescriptions and mitigation measures include avoidance, short-term deferral, specific harvest and yarding method, restoration, active downed wood and large woody debris management, and other measures. Site-specific harvest planning will determine the combination and configuration of restoration activities to best meet stand level objectives and minimize effects to riparian areas and aquatic resources. Such plans would be analyzed at the project level using the expanded State Environmental Policy Act Environmental Checklist. Higher levels of mitigation in the form of monitoring may be necessary for the Preferred Alternative and Alternatives 5, due to relatively higher levels of forest management activity in riparian zones. Monitoring of harvest operations may be necessary to assess the level of impact in future operations and to ensure the thinning activities result in the benefits of accelerated forest development.

The Habitat Conservation Plan's Implementation Agreement (see Appendix C) addresses adaptive management. It directs the DNR to refine "management activities allowed within the Riparian Management Zones … within the first decade of the HCP." As noted previously, the DNR has worked extensively with the Federal Services and the Washington Department of Fish and Wildlife to develop a strategy for management activities within the Riparian Management Zone. When finalized, the DNR will file a State Environmental

Policy Act Environmental Checklist, seeking additional review of the proposal. If there are changes that would require different sus tainable forest management strategies not envisioned today, then the DNR may recommend that the Board of Natural Resources make appropriate changes, that could include re-running the sustainable forestry model and examining the changes' impacts on the sustainable harvest level; this dynamic approach is consistent with the Board's *Sustainable Harvest Calculation Management Principles and Objectives* (see Resolution 1110, Appendix F).

4.4 WILDLIFE

4.4.1 Summary of Effects

This section analyzes the environmental effects on wildlife resources and examines the effects of prospective changes to current policy and procedures under the different Alternatives. The analysis also allows DNR and policy makers to assess relative risks that are illustrated using modeling outputs.

None of the Alternatives, including the Preferred Alternative, proposes changes to the northern spotted owl conservation strategy, as outlined in the Habitat Conservation Plan (HCP) on pages IV.1 to IV.19 and IV.86 to IV.106 (DNR 1997). The HCP Environmental Impact Statement (EIS) is incorporated by reference (DNR 1996) and relied on in this Final EIS. In addition, this Final EIS analyzes the Alternatives in light of the new information on northern spotted owl demography discussed in section 4.4.3 of this document. The analysis also includes a comparison of the Alternatives using three criteria:

- changes in the amount of structurally complex forest;
- the amount of timber harvest in areas designated as Nesting, Roosting, and Foraging Management Areas and Dispersal Management Areas; and
- changes in the management of northern spotted owl circles.

Other policy and procedure changes under the Alternatives would influence the amount and distribution of wildlife habitat on western Washington forested state trust lands. The Alternatives would vary in the timing and amount of forest structures they would create, but would not be expected to have any significant adverse environmental effects on wildlife.

The sustainable harvest calculation analysis uses the stand development stages to represent structural diversity and habitat values. (Descriptions of these stand development stages are provided in Appendix B, Section B.2.3.) Changes in the relative amount of forested habitat types are a product of varying rates and intensities of timber harvest under the different Alternatives. Appendix D, Table D-12 presents the modeled proportion of forested trust lands comprising ecosystem initiation, competitive exclusion, and structurally complex forests under each Alternative in the years 2013 (short-term) and 2067 (long-term). Competitive exclusion forests are the most common forest habitat type on forested trust lands, making up 68 percent of the total forested area (Table 4.4-1). Approximately 26 percent of this habitat type occurs in Upland Areas with General Management Objectives. Structurally complex forest makes up about 25 percent of the total area on western Washington forested state trust lands (Table 4.4-1). In the short term and long term, the amount of structurally complex forest is modeled as increasing in all HCP Planning Units under all Alternatives.

The structurally complex forest stages serve as a relative indicator of change in the amount of habitats of management concern. Several examples follow:

- Northern Spotted Owl - Throughout much of their range, northern spotted owls are strongly associated with forested areas that are classified as structurally complex in this Final EIS.
- Marbled Murrelet - The *Marbled Murrelet Recovery Plan* (USFWS 1997) identifies terrestrial (upland) habitat essential for marbled murrelet recovery. The Recovery Plan identifies additional areas on non-federal land where existing habitat should be protected because habitat in federal reserves is insufficient to reverse population declines and maintain a well-distributed population. In the state of Washington, such additional essential habitat occurs on state lands within 40 miles of marine waters. These areas are critical for improving the distribution of the population and suitable habitat, especially in southwestern Washington (USFWS 1997). Effects on forestlands within 40 miles of marine waters, therefore, are of particular concern in determining the effects of the Alternatives on marbled murrelet populations. Of the approximately 340,000 acres of structurally complex forest on forested trust lands (Table 4.4-1), approximately 85 percent occur within 40 miles of marine waters (see Table D-16).
- Deer and Elk - The results from the Washington Forest Landscape Management Project (1996) indicated that the estimated carrying capacities for deer and elk are comparable when either timber production is maximized, or when 30 percent of the watershed is maintained in a fully functional forest stage.

Forest in the competitive exclusion stages is currently the most abundant habitat type on forested trust lands. Under all Alternatives, the majority of timber harvest is expected to occur in this habitat type. Two processes would likely affect the amount of competitive exclusion forest: conversion to ecosystem initiation forest through high-volume timber harvest, and development into structurally complex forest through natural forest succession, as well as forest management activities such as thinning.

Model output data indicate that the amount of competitive exclusion forest on western Washington forested state trust lands would decline under all six Alternatives in both the short term and the long term (Figure 4.4-3). In the short term, results show very little difference in the amount of competitive exclusion forest among the Alternatives (Appendix D, Table D-12). Model outputs indicated that at the end of the planning period, by 2067, all Alternatives would reduce the amount of forestlands in competitive exclusion, ranging from 1 to 8 percent. Under Alternatives 1, 4, and 5, approximately 65 percent of western Washington forested state trust lands would consist of competitive exclusion forest, while Alternatives 2, and 3 would result in about 64 percent. Under the Preferred Alternative, 60 percent of the forested trust lands would consist of competitive exclusion forest (Appendix D, Table D-12).

For the most part, decreases in the amount of competitive exclusion forest correspond to increases in the amount of structurally complex forest. This result suggests that many areas that currently sustain competitive exclusion forest would acquire the characteristics of structurally complex forest over time. The greatest long-term declines in competitive exclusion forest would likely occur under the Preferred Alternative, followed in descending order by Alternatives 1, 4, and 5, and then 2 and 3. Declines in the amount of competitive exclusion forest would not be expected to result in any significant adverse effects to wildlife species overall. No wildlife species are found exclusively in competitive exclusion forests, and decreases in the amount of competitive exclusion forest would nearly be matched by increases in structurally complex forest.

4.4.2 Introduction

This section identifies the potential effects of each forest management Alternative regarding proposed changes to policies and procedures on wildlife species and their habitats. Included is how these effects may differ among the six Alternatives. Appendix C provides an overview of the policies and procedures that govern DNR's management of wildlife resources, as well as those that influence the quality, quantity, and distribution of various wildlife habitats on the forest landscape. The Affected Environment section discusses wildlife habitats and species of special interest that are affected by current forest management. Finally, this section describes how procedural changes under the proposed Alternatives could affect wildlife habitats and populations.

Wildlife-related issues raised during internal DNR and public scoping processes include:

- the amount, quality, and distribution of northern spotted owl habitat over time (and forest structure in general). The status of the northern spotted owl population in southwestern Washington was highlighted as a matter of particular concern;
- the protection of currently suitable habitat for other listed species or species of concern such as the marbled murrelet;
- the maintenance of habitat features that contribute to biological diversity (e.g., snags, dead and down woody material, canopy gaps); and
- the potential for harvest levels to be affected by conservation measures for uncommon habitats.

4.4.3 Affected Environment

4.4.3.1 Habitats

This section describes five general types of wildlife habitat that occur on forested trust lands, provides examples of species associated with these habitats, and describes their prospective and current distribution among Habitat Conservation Plan (HCP) Planning Units.

The five wildlife habitat types addressed in this analysis are:

- ecosystem initiation forest,
- competitive exclusion forest,
- structurally complex forest,
- riparian and wetland habitats, and
- uncommon habitats.

The first three habitat types consist of groupings of stand development stages, which are a method of classifying forest stands according to various levels of structural and vegetative complexity (Johnson and O'Neil 2001). Table 4.2-4 provides the current distribution of stand development stages on forested trust lands. The total acreage of these habitat types by HCP Planning Unit is summarized in Table 4.4-1.

Ecosystem Initiation Forests

Ecosystem initiation forests represent the initial phases of forest development following a major disturbance such as a fire or regeneration harvest. They correspond to the grass/forb and shrub/sapling forest structure classes. Young forest stands with an open canopy and plentiful shrub cover support a diverse assemblage of birds; bird species diversity and overall abundance is highest in stands in the ecosystem initiation stage (Carey et al. 1996).

Ecosystem initiation stands also provide abundant forage for wide-ranging ungulate species (deer and elk). Other species closely associated with this stage include the white-tailed ptarmigan, yellow-breasted chat, and Townsend's vole (Johnson and O'Neil 2001). Structural legacies (e.g., large snags and down logs) retained from the previous stand can increase biological diversity by providing habitat for small mammals, cavity-nesting birds, and terrestrial amphibians (Carey et al. 1996). In managed landscapes, retention of such legacies combined with a management program designed to promote biological diversity may speed the development of more-complex forest ecosystems (Carey and Curtis 1996; Carey et al. 1996; Carey 1998).

Table 4.4-1. Acres of Wildlife Habitat Types among Forested Trust Lands by Habitat Conservation Plan Planning Unit

	HCP Planning Unit						
Habitat Type	**Columbia**	**N. Puget**	**OESF[5/]**	**S. Coast**	**S. Puget**	**Straits**	**Total**
Ecosystem Initiation Forest	18,331	31,540	17,823	16,778	11,607	9,160	105,240
Competitive Exclusion Forest[1/]	189,755	244,178	169,571	173,472	94,661	72,986	944,623
Structurally Complex Forest[2/]	59,444	105,798	69,265	42,681	35,575	28,076	340,841
Total Forested Trust Lands	**267,530**	**381,516**	**256,659**	**232,931**	**141,843**	**110,222**	**1,390,704**
Other Lands (including many uncommon habitats)[3/]	26,124	51,892	13,872	23,544	16,527	7,083	139,042
Riparian Areas and Wetlands[4/]	86,443	92,724	111,308	80,966	34,606	20,684	426,731

Data Source: Model output data – stand development stages.
1/ Includes sapling exclusion, pole exclusion, large tree exclusion, and understory development stages.
2/ Includes botanically diverse, niche diversification, and fully functional stages.
3/ Includes road rights-of-way, lakes and rivers, non-inventoried lands, and non-forested lands (e.g., grasslands, agricultural areas, utility easements, developed lands, beaches, bare rock, snow, and ice).
4/ Riparian areas are defined by buffers along streams, and wetlands include forested and non-forested wetland types. As such, both riparian areas and wetlands overlap other habitat types (including each other) and are not included in total area calculations. See Section 4.9.3 for a discussion of how wetlands were identified for this analysis.
5/ OESF = Olympic Experimental State Forest

Currently, about 8 percent of western Washington forested state trust lands consist of ecosystem initiation forest (Table 4.4-1); about 42 percent of this occurs in Upland Areas with General Management Objectives.

Competitive Exclusion Forests

Forests in the competitive exclusion stages generally have a single, dense canopy layer dominated by trees between 10 and 30 inches or greater in diameter at breast height. Small snags and down logs are often present, the result of suppression mortality as trees compete for available resources. Large decaying logs and stumps may be present as remnants of previous disturbances, such as windstorms or harvests.

In younger competitive exclusion stands, the high density and uniform size of relatively short trees allows only small amounts of sunlight to reach the forest floor, creating sparse understory conditions and low levels of biological diversity. Canopy gaps—either as a result of thinning or natural mortality—allow understory plants to become established. The result is a gradual increase in biological diversity. The competitive exclusion stages have the lowest biodiversity and the least favorable conditions for wildlife when compared to all the stand development stages (Carey et al. 1996). No wildlife species in western Washington are found exclusively in competitive exclusion forests (Carey and Curtis 1996).

Competitive exclusion forests are the most common forest habitat type on DNR-managed forested trust lands, making up 68 percent of the total forested area (Table 4.4-1). Approximately 26 percent of this habitat type occurs in Upland Areas with General Management Objectives. In this analysis, the understory development stage is included in the competitive exclusion stage because it has not yet developed the characteristics associated with structurally complex forests (as discussed below).

Structurally Complex Forests

Structurally complex forests typically feature multiple canopy layers, with the top layer of trees 20 to 30 inches and greater in diameter at breast height. In the more fully developed stages, such as niche diversification and fully functional, snags and down logs play a vital role in providing structural and biological diversity (Appendix B, Section B.2).

Biological diversity in this forest habitat type is promoted by structural complexity along both the vertical axis (i.e., trees of different heights, as well as shrubs and herbaceous plants) and the horizontal axis (e.g., gaps in the forest canopy) (Carey et al. 1996; Franklin et al. 2002). A diversity of plant species and growth forms in structurally complex forest provides niches for a wide variety of wildlife species. For example, structurally complex forests have an understory of small trees, shrubs, ferns, and herbs, providing foraging opportunities for herbivores and breeding habitat for ground-nesting birds (Carey et al. 1996). Large snags and down logs in the more fully developed stages of this class (or in other stages, if present as legacies) may provide suitable habitat conditions for a variety of species of conservation interest, including nest sites for northern spotted owls, roost sites for bats, and den sites for Pacific fishers. Very large trees may also provide nest sites for other wildlife species, including bald eagles and marbled murrelets.

Structurally complex forest makes up about 25 percent of the total forested area on DNR-managed forested trust lands (Table 4.4-1). Among the HCP Planning Units, the North Puget HCP Planning Unit supports the highest proportion (28 percent) and the South Coast

HCP Planning Unit supports the lowest (18 percent) of this forest habitat type. Currently, about 20 percent of the structurally complex forest on forested trust lands occurs in Upland Areas with General Management Objectives; the other 80 percent occur in Riparian and Wetland Areas or Uplands with Specific Management Objectives (which includes the entire Olympic Experimental State Forest). Including all western Washington forested state trust lands in deferred status, approximately 22 percent of all forested trust lands are managed under general management objectives (Table 4.4-1).

Riparian and Wetland Habitats

Water plays a significant role in the development of landforms and vegetation in riparian and wetland areas, which are defined more fully in Sections 4.3 and 4.9, respectively. Riparian habitats range from headwater streams and seeps to broad, flat river valleys. Wetlands include both forested and non-forested types. Numerous wildlife species use riparian and wetland habitats to fulfill all or portions of their life requisites such as breeding, foraging, resting, and traveling from one geographical area to another. Examples of species associated with these habitat types include beaver, mink, river otter, waterfowl, herons, and most amphibian species. In addition, several threatened, endangered, and sensitive species depend on riparian and wetland habitats for some or all of their life requisites (see Appendix D, Table D-11). Riparian and wetland habitats occur throughout all the five Westside HCP Planning Units and the Olympic Experimental State Forest, and encompass about 31 percent of the DNR-managed forested trust lands (Table 4.4-1).

Uncommon Habitats

While the great majority of forested trust lands supports forests of various structural classes, uncommon habitats also play a significant role in providing the life requisites of many wildlife species. Cliffs and talus, for example, provide habitat for species such as peregrine falcons, pikas, mountain goats, and Larch Mountain salamanders. Native grasslands serve as breeding and foraging areas for numerous bird and mammal species, and support host plants for certain rare butterfly species. Oak woodlands warrant specific consideration in the DNR Habitat Conservation Plan (HCP) due to the rarity of this habitat type and its role in supporting some uncommon wildlife species such as the Lewis' woodpecker and western gray squirrel. Available data distinguish between forested and non-forested areas but do not identify individual uncommon habitats on forested trust lands. "Other Lands" identified in Table 4.4-1 include such non-forested land cover types as grasslands, agricultural areas, utility easements, developed lands, beaches, bare rock, snow, and ice. Also included in the total acreage of "Other Lands" are road rights-of-way (58,000 acres total), lakes and rivers (9,000 acres total), and recently acquired lands that have not yet been inventoried.

4.4.3.2 Species of Interest

Most species of interest in this Final Environmental Impact Statement are those with a regulatory status that indicates particular concern for their viability, either off or on DNR-managed forested trust lands, such as species classified as threatened, endangered, or sensitive under Washington Administrative Code 232-12-297.

The northern spotted owl and marbled murrelet receive particular attention due to their listing status under the federal Endangered Species Act, their close association with structurally complex forest, and their occurrence on western Washington forested state trust lands. Other species of management interest are deer and elk, which are game species of cultural significance to tribal and other hunters, and are also valuable prey species for wolves and other large predators. Salmonids are addressed in Section 4.10, Fish. The 1997 Habitat Conservation Plan and associated Environmental Impact Statement (DNR 1997, 1996) are the primary sources of information about species addressed in this section. Where changes have occurred in the regulatory status of an individual species, or in the understanding of its habitat associations and population status, information is updated accordingly in the subsections below.

Northern Spotted Owl

Throughout much of their range, northern spotted owls are strongly associated with forested areas that are classified as structurally complex in this Final Environmental Impact Statement. Northern spotted owl habitat requirements are addressed in DNR's Habitat Conservation Plan (HCP) through the provision of Nesting, Roosting, and Foraging Management Areas and in Dispersal Management Areas. Nesting, roosting, and foraging habitat corresponds roughly with forested areas that are classified as structurally complex. Dispersal habitat is likely met in closed-canopy stands in the pole and large tree exclusion, and understory development stages, which are all part of the competitive exclusion stage (Section 4.2, Table 4.2-4) in addition to all the stages that make up structurally complex forest.

Notably, the stand development stages in this document are defined using a different set of criteria than the habitat definitions described in the Habitat Conservation Plan (HCP). When the HCP was signed in 1997, forest structure was identified primarily by the age of the stand. However, as new data and science have become available, stand age has become somewhat less important as a measure of structural development because it does not incorporate physical attributes or structural components important for characterizing habitat. These structural components include snags, understory development, and down woody debris. This analysis uses a stand development stage model instead of age to better represent structural diversity and habitat values. Structurally complex forests and nesting, roosting, and foraging habitat are similar enough that, for this analysis, structurally complex forest can serve as an index to the relative changes in the amounts of nesting, roosting, and foraging habitat over time under the proposed Alternatives.

The Role of Forested Trust Lands in Northern Spotted Owl Conservation

Federal lands were determined to be the key for northern spotted owl conservation, whereas non-federal lands were expected to complement the effort for species stabilization and recovery (USDI 1992). The U.S. Fish and Wildlife Service designated spotted owl critical habitat solely on federal lands (USDI 1992).

Several analyses published in early 1990s discussed the contribution of federal and non-federal lands in northern spotted owl conservation:

1. The final draft Recovery Plan for the Northern Spotted Owl (USDI 1992) recommended establishment of conservation areas on federal lands as the primary means for achieving recovery of the northern spotted owl. It also discussed the management recommendations for the areas where federal lands alone would be insufficient to achieve the recovery objectives.
2. The Forest Ecosystem Management Assessment Team northern spotted owl viability panel assessed the Northwest Forest Plan management options and predicted an 83 percent likelihood that habitat conditions would provide for well-distributed, stable populations of northern spotted owls on federal lands (USDA et al. 1993).
3. The report of the Spotted Owl Advisory Group to the Washington Forest Practices Board (Hanson et al. 1993) identified the important non-federal landscapes for essential northern spotted owl habitats on non-federal lands in Washington (the term "essential habitat" is different from the "critical habitat" as defined in the Endangered Species Act), and provided recommendations for site- and landscape-specific plans. These important landscapes were named Spotted Owl Special Emphasis Areas.
4. The Re-analysis Team (Holthausen et al. 1995) conducted additional analysis on persistence of the northern spotted owl population on the Olympic Peninsula and concluded that "it is likely but not assured, that a stable population would be maintained on portions of the Olympic National Forest and the core area of the national park in absence of any non-federal contribution of habitat."

DNR considered all these analyses when developing the northern spotted owl conservation strategy in the Habitat Conservation Plan.

About 8 percent of the known northern spotted owl site centers in the state of Washington recorded in the Washington Department of Fish and Wildlife database as a result of 10 years of inventory surveys (1986 to 1995), occurred on DNR-managed forested trust lands in 1996 (USDI 1997) (Figure 4.4-1). (Washington Department of Fish and Wildlife Status 1, 2, or 3 northern spotted owl sites represent reproductive pair, pair – status unknown, and territorial single sites, respectively.)

These site centers were distributed among federal and DNR-managed forested trust lands as follows: in western Washington there were 389 site centers on federal land and 35 on forested trust lands; on the Olympic Peninsula, there were 203 site centers on federal land and 25 on forested trust lands; and in eastern Washington, 227 site centers were on federal land and 16 on forested trust lands.

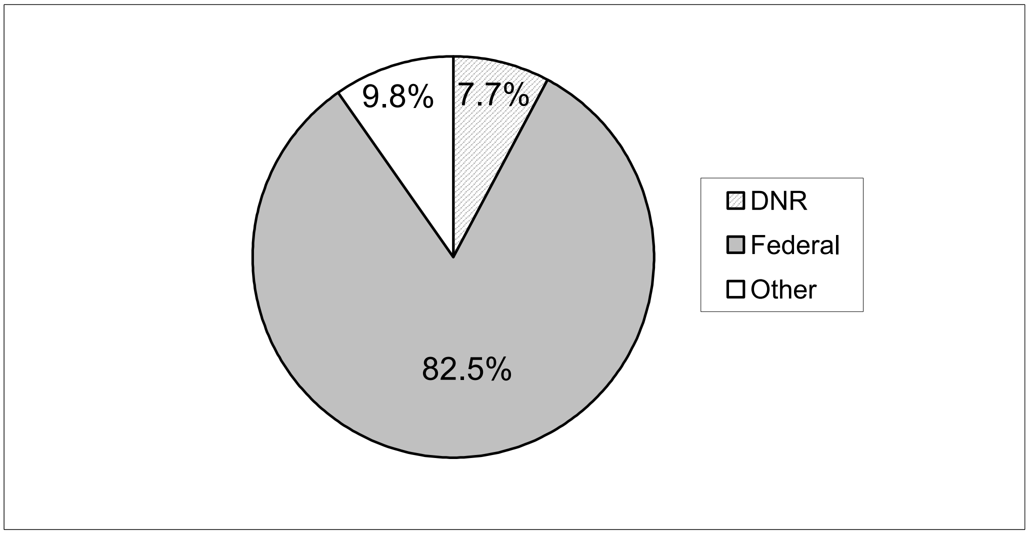

Figure 4.4-1. Percentage of Known Territorial Northern Spotted Owl Site Centers (WDFW Status 1, 2, 3) by Ownership in Washington in 1996

About 12 percent of the potentially suitable northern spotted owl habitat in the state of Washington in 1996 was on DNR-managed forested trust lands (USDI 1997) (Figure 4.4-2). “Suitable habitat” was defined as a mix of habitat qualities that provide for some or all of the life needs of the northern spotted owl, and this definition did not include habitat that only meets dispersal function.

In 1996, there were 145 known territorial northern spotted owl site centers (Status 1, 2 or 3) that influenced forested trust lands in the five Westside HCP Planning Units (i.e., these sites occurred either on or within a median home range radius of forested trust lands); 42 additional sites were projected to exist. In the three Eastside HCP Planning Units, there were 78 known northern spotted owl circles (Status 1, 2 or 3) that contained forested trust lands; 23 unknown site centers were projected to exist within the median home range radius of forested trust lands. There were 69 known northern spotted owl sites within 2.7 miles of forested trust lands in the Olympic Experimental State Forest (DNR 1996).

In general, areas with larger continuous habitat patches, which support clusters of 20 or more northern spotted owls, were considered to have the likelihood of being self-sustaining (Thomas et al. 1990). A plausible assumption was made in the Habitat Conservation Plan (HCP) Draft Environmental Impact Statement (EIS) that many of the owl habitats on federal reserves would act as source areas (in which the reproductive rate of the population exceeds the mortality rate). Forested trust lands within 4 miles of the federal reserves that provide habitat for northern spotted owls would probably act more often like sink areas (in which the mortality rate exceeds the reproduction rate and thus the persistence of the owls there relies on the emigrants from the source areas) because of the

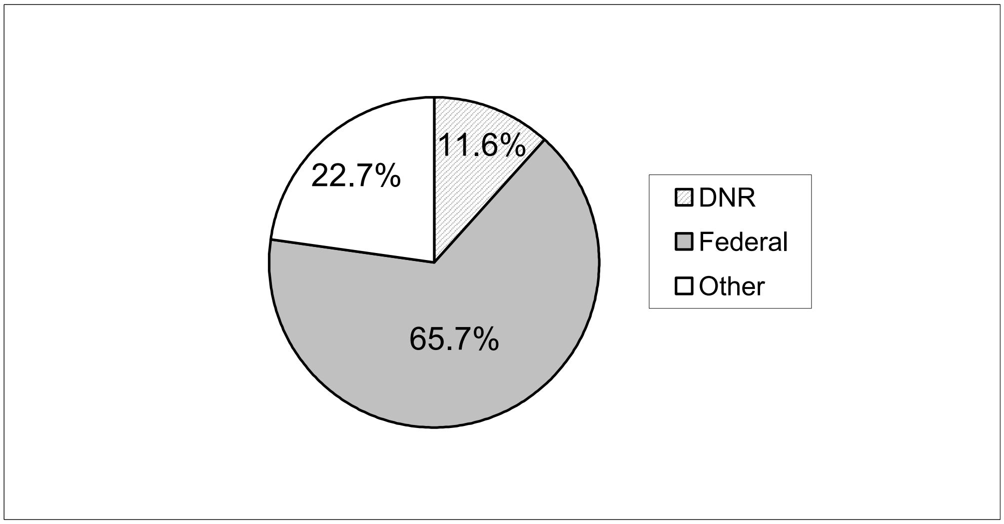

Figure 4.4-2. Percentage of Suitable Northern Spotted Owl Habitat by Ownership in Washington in 1996

small amount of forested trust lands in suitable habitat and because of its fragmentation. They can still provide demographic support to the population, at least occasionally.

The recommendations of the northern spotted owl Recovery Team (USDI 1992) and the Spotted Owl Advisory Group (Hanson et al. 1993) were taken into consideration during the designation of the Nesting, Roosting, and Foraging Management Areas and Dispersal Management Areas near federal lands. These areas were established primarily within 4 miles of the federal lands. The designation was supposed to provide habitat that makes a significant contribution to demographic support, maintenance of species distribution, and facilitation of dispersal. Based on the analyses conducted for the HCP, potential negative effects to individual northern spotted owls outside those areas were not expected to result in significant adverse effects to recovery efforts for the northern spotted owl population in western Washington (DNR 1996).

In the Biological Opinion for the HCP (USDI 1997), it was assumed that all suitable habitat inside northern spotted owl circles outside of the Nesting, Roosting, and Foraging Management Areas and Dispersal Management Areas would be harvested within the first decade of the HCP. However, an important commitment made by the DNR in the HCP was to consider U.S. Fish and Wildlife Service recommendations when harvesting northern spotted owl habitat outside of designated Nesting, Roosting, and Foraging Management Areas during the first decade of the HCP. The DNR, Washington Department of Fish and Wildlife, and U.S. Fish and Wildlife Service Interagency Technical Group developed a northern spotted owl Site Prioritization Schedule in October 1997. Emphasis and recommendations centered on Category 1 northern spotted owl circles (i.e., circles that overlap harvestable Nesting, Roosting, and Foraging Management Areas; Spotted Owl Special Emphasis Areas outside of Nesting, Roosting, and Foraging Management Areas; and circles that are outside of both Spotted Owl Special Emphasis Areas and Nesting, Roosting, and Foraging Management Areas). These northern spotted owl circles were identified as potentially having a valuable short-term contribution to the population. A total of 234 site centers were considered "at risk." Of these, the Interagency Technical Group designated 66 "critical owl circles," which the U.S. Fish and Wildlife Service asked the DNR to protect during the HCP's first decade (USFWS et al. 1997).

The DNR committed to provide additional protection for the highest priority 56 northern spotted owl circles of the 66 circles the U.S. Fish and Wildlife Service identified. These 56 owl circles became known as "Memorandum #1 owl circles," after the January 1998, HCP Implementation Memorandum #1 which deferred harvests in these circles until 2007 (the end of the HCP's first decade). Outside of the Nesting, Roosting, and Foraging Management Areas and Dispersal Management Areas and outside of the Memorandum #1 northern spotted owl circles, management activities within all other northern spotted owl circles could proceed if they were consistent with the timber sale design commitments in the HCP (IV.9-10, DNR 1997).

Beyond Memorandum #1, DNR Procedure 14-004-120 provided protection from harvesting of suitable habitat within all Status 1 reproductive owl circles and within four specific northern spotted owl circles in Southwest Washington (*Management Activities Within Spotted Owl Nest Patches, Circles, Designated Nesting, Roosting, and Foraging, and Dispersal Management Areas,* dated August 1999).

Proposed changes to this procedure as outlined in the Preferred Alternative (see Appendix F) include a strategy that is intended to provide habitat that makes a significant contribution to demographic support, the maintenance of distribution, and the facilitation of dispersal. This strategy is designed to create a landscape in which active forest management plays a role in the development and maintenance of the structural characteristics that constitute such habitat over both the short term and long term as new habitat develops (see Chapter 2, Section 2.6.3.5 for additional discussion). Currently, 28 Owl Memorandum #1 circles are identified as overlapping western Washington forested state trust lands, along with 78 Status 1 reproductive circles and 4 southwestern Washington northern spotted owl circles. A total of 11 northern spotted owl circles have been identified in southwestern Washington; however, 7 of the 11 owl circles are included above in either the Owl Memorandum #1 northern spotted owl circles or Status 1 reproductive circles. Timber harvest activities within the habitat portion of these circles is deferred for the first decade of HCP implementation.

In Nesting, Roosting, and Foraging Management Areas and Dispersal Management Areas, the HCP requires DNR to identify at least 50 percent of designated habitat management area as the "threshold habitat target" within each watershed. However, the HCP allows harvests in watersheds designated as Nesting, Roosting, and Foraging Management Areas that do not yet contain the 50 percent threshold, if those harvest activities do not increase the amount of time that would be required for the target amount of Nesting, Roosting, and Foraging goal (50 percent habitat threshold) to be attained if all the stands in that watershed were left unmanaged (IV.8-9, DNR 1997).

NEW DATA ON NORTHERN SPOTTED OWL DEMOGRAPHY

When the Habitat Conservation Plan (HCP) was completed in 1997, several studies had described northern spotted owl populations that were declining in many parts of their range, but the magnitude of these declines was a matter of much debate (Anderson and Burnham 1992; Thomas et al. 1993; Burnham et al. 1994; Bart 1995).

The annual rate of population change ("λ," where λ=1 refers to a stable population and λ< 1 refers to a declining population) used in the HCP Draft Environmental Impact Statement (EIS) analyses were those presented in Burnham et al (1994) in the Final Supplemental EIS for the Northwest Forest Plan.

Two long-term demographic study areas used in the federal monitoring program for the northern spotted owl, that applied to Washington northern spotted owl provinces, were used in the HCP analysis—the Olympic Peninsula study area and the Cle Elum study area. The value of λ from the Cle Elum study area was used to define the northern spotted owl population status in the Eastside HCP Planning Units. It was estimates as 0.924—a negative 7.6 percent annual rate of change; the 95 percent confidence intervals of λ were 0.8610 and 0.987. The annual rate of population change on the Olympic Peninsula was 0.9472, a 5.3 percent decline per year. For the Westside HCP Planning Units, the value of λ was averaged for the two study areas to give a population change of 0.9356—an annual rate of decline of 6.4 percent. The 95 percent confidence intervals for the westside were 0.8789 and 0.9922. As discussed in the Final Supplemental EIS for the Northwest Forest Plan (USDA and USDI 1994), such a rapid rate of decline seemed inconsistent with the observations from population density studies at that time. The upper limits of the confidence intervals were considered to be closer to the reality than the midpoint. They equaled an annual rate of decline of 0.8 percent for the westside and 1.3 percent for the eastside. DNR used these upper limits in their HCP analyses.

Additional research since 1996 has provided further evidence that northern spotted owl populations are continuing to decline. Analysis by Franklin et al. (1999) resulted in a point estimate for the Cle Elum study area for the period 1989 to 1998 of λ = 0.9406 (juvenile survival was not corrected for emigration) with lower and upper 95 percent confidence intervals of 0.8963 and 0.9848, respectively. The point estimate for the Olympic Peninsula study area for the period 1987 to 1998 was λ=0.8763 (juvenile survival was not corrected for emigration) with lower and upper 95 percent confidence intervals of 0.8449 and 0.9077, respectively. A derivation of λ for the Westside HCP Planning Units, calculated as an average from the Cle Elum and Olympic Peninsula point estimates, would be 0.9085. These data confirmed the northern spotted owl population decline with greater statistical power because of the larger samples used in the analyses.

Preliminary results from the last northern spotted owl demography workshop held in January 2004 (Anthony et al. 2004) concluded that northern spotted owl populations on many of the study areas decline even more rapidly compared to the rates from the 1999 report. The estimates of the population rate of change were especially low for the state of Washington, indicating a decline of 7.5 percent per year for the entire period of study

(1987 to 2003). For comparison, the decline in Oregon was 2.8 percent per year and in California 2.2 percent per year. The annual rate of population change was calculated differently in 2004 than in the previous demography reports (Burnham et al. 1994; Franklin et al. 1999). The main difference between the two methods is that the earlier λ estimates (λ_{PM}) were computed from projection matrices using age-specific survival and fecundity from juvenile, subadult, and adult owls, assuming a stable distribution, while the current λ estimate (λ_{RJS}) refers to the population of territorial owls only and takes into account the combination of gains and losses to the population by direct estimation from the capture-recapture data. The opinion of the authors of the 2004 report is that λ_{PM} is biased low (which means it estimates greater population decline) and only λ_{RJS} should be used.

According to the 2004 report, the populations on the Cle Elum, Wenatchee, and Mt. Rainier study areas declined substantially over the last decade. The population sizes were approximately 40 to 60 percent of initial populations in the Cle Elum and Wenatchee study areas. The Olympic Peninsula population in 2002 was approximately 70 to 80 percent of initial populations. “Initial populations” here refers to the time the demography studies started, which for these areas is late 1980s and early 1990s.

Anthony et al. (2004) did not provide analyses on the causes for the recent rapid decline. The report only suggested the possible reasons for the dramatic decline in Washington study areas: 1) high density of barred owls, 2) loss of habitat due to wildfire, 3) logging of northern spotted owl habitat on state and private lands, 4) forest defoliation caused by insect infestations, and 5) advancing forest succession toward climax for communities (e.g., *Abies spp*.) in the absence of wildfires. Related to the fifth reason above, the natural progression of a stand to climax (that is, stands that evolve in the absence of major disturbance) results in forests that are no longer northern spotted owl habitat.

More definitive information of the causes of decline is anticipated in the U.S. Fish and Wildlife Service 5-year status report for northern spotted owl, which will be available later this year (2004).

Marbled Murrelet

Reflecting the lack of certainty about the specific habitat needs of marbled murrelets, the Habitat Conservation Plan (HCP) defined an interim conservation strategy for this species. The interim strategy for marbled murrelets involves habitat relationship studies designed to identify higher quality habitats that have the greatest potential to support nesting murrelets. These studies have not been completed in all five Westside HCP Planning Units and the Olympic Experimental State Forest; therefore, analyses in this Final Environmental Impact Statement (EIS) take a more general approach, using structurally complex forest as an indicator for suitable nesting habitat for marbled murrelets.

Analyses conducted for DNR’s HCP EIS (DNR 1996) indicate that most forest stands greater than 110 years of age have sufficient numbers of nesting platforms to support murrelets. Model output data for 2004 show that most forests classified as structurally complex are at least 90 years old, so it is likely that there is considerable overlap between structurally complex forest and murrelet nesting habitat.

The Marbled Murrelet Recovery Plan (USFWS 1997) identifies terrestrial (upland) habitat essential for marbled murrelet recovery. The Recovery Plan identifies additional areas on non-federal land where existing habitat should be protected because habitat in federal reserves is insufficient to reverse population declines and maintain a well-distributed population. In the state of Washington, such additional essential habitat occurs on state lands within 40 miles of marine waters. These areas are critical for improving the distribution of the population and suitable habitat, especially in southwestern Washington (USFWS 1997). Effects on forestlands within 40 miles of marine waters, therefore, are of particular concern in determining the effects of the Alternatives on marbled murrelet populations.

Of the approximately 341,000 acres of structurally complex forest on forested trust lands (Table 4.4-1), approximately 84 percent of this forest development stage occurs within 40 miles of marine waters. Relative to all DNR-managed forested trust lands, the estimated proportion of structurally complex forest within 40 miles of marine waters is 21 percent (see Appendix D, Table D-16). The DNR currently identifies three types of marbled murrelet habitat:

1. Forest stands identified as habitat as a result of DNR's marbled murrelet habitat relationship study (referred to as "reclassified habitat");
2. Occupied forest sites identified in the Washington Department of Fish and Wildlife point database as a result of DNR's marbled murrelet-habitat relationship study and field surveys (referred to as "occupied habitat"); and
3. Occupied forest stands defined as the occupied stand and all reclassified habitat located within one-half mile of the occupied forest stand.

In the absence of more specific information on the long-term conservation strategy, it is assumed for this analysis that all marbled murrelet occupied sites, reclassified habitat, and occupied forest stands will be maintained in a long-term deferred status. The assumption for the remainder of the forest stands will be changed from a deferred status to an un-deferred status. The net effect of these assumptions will be that 55 percent (approximately 81,000 acres) of identified marbled murrelet reclassified habitat will be maintained in a long-term deferred status, and the remainder placed into the Riparian and Wetland Areas or Upland Areas with Specific Objectives land classes, depending on the proximity to Riparian Areas. None of the marbled murrelet reclassified habitat or occupied forest stands will be placed in Upland Areas with General Objectives, the land class with the fewest harvest restrictions. It is assumed for this analysis that all marbled murrelet reclassified habitat will be deferred until a long-term strategy is developed.

The HCP long-term strategy was intended to help meet objectives of the federal Marbled Murrelet Recovery Plan (USFWS 1997), and to "...make a significant contribution to maintaining and protecting marbled murrelet populations in western Washington…" (DNR 1997, p. IV.44).

The HCP provided a high level discussion of the long-term strategy, including the "...general factors that would likely be considered... [and] …an idea of the kinds of approaches expected...” Three forest-related factors were thought to be primary negative influences on murrelet populations:

1. Loss of nesting habitat mainly due to timber harvest;
2. The speculation that predation at nest sites is a major impact to recruitment of young birds into the population and to adult survival rates; and
3. The suspicion that logging-related disturbance of nesting birds significantly reduces nest success.

DNR then presented a series of considerations that were thought to be important to developing a conservation strategy in the context of those primary factors and assumptions that marbled murrelets had limited dispersal abilities and may be unable to colonize new breeding habitat. Those considerations generally belonged in one of the following categories: 1) stand-level issues at marbled murrelet breeding areas; 2) landscape-level issues; and 3) issues of conservation biogeography.

Nine HCP Planning Units comprise forested trust lands under the HCP; marbled murrelets inhabit all five westside HCP Planning Units and the Olympic Experimental State Forest. Information-gathering and marginal habitat release are in progress in the North and South Puget HCP Planning Units, and have been substantially completed in the Olympic Peninsula (Straits and Olympic Experimental State Forest HCP Planning Units) and southwest Washington (South Coast and Columbia HCP Planning Units). As agreed to in the HCP (DNR 1997, p. IV.40), DNR and the U.S. Fish and Wildlife Service are initiating the process of developing the long-term marbled murrelet conservation strategy for these four HCP Planning Units, which encompass part of Conservation Zone 1 and all of Zone 2 designated in the Recovery Plan (USFWS 1997).

Land ownership patterns, densities of marbled murrelets at sea, and DNR inland survey results vary dramatically among the HCP Planning Units. The Olympic Peninsula is approximately 2.8 million acres, the majority of which (1.6 million acres) are federal lands in the Olympic National Park and Olympic National Forest. DNR manages approximately 380,000 acres of land in this particular area. DNR-managed forested trust lands in the Olympic Experimental State Forest HCP Planning Unit (270,000 acres) are spread across a fairly broad (approximately 20 mile) coastal plain and the foothills of the Olympic Mountains, in contrast to those in the Straits HCP Planning Unit (112,000 acres) that are confined to a narrow band of non-federal land between the Olympics and the Pacific Ocean. The western portions of the Columbia and South Coast HCP Planning Units are dominated by private lands (mostly commercial forest), with federal lands mostly peripheral to the marbled murrelet’s inland range. South of the Olympic Peninsula and within the range of the marbled murrelet, these two HCP Planning Units comprise approximately 3.5 million acres, of which about 10 percent is forested trust lands managed by DNR.

Marbled murrelet activity recorded during DNR inland surveys was greatest in the Olympic Experimental State Forest HCP Planning Unit, with 6,909 marbled murrelet detections recorded on 34 percent of 4,584 surveys. Next, in the Straits HCP Planning

Unit, 1,060 detections were recorded on 14 percent of 2,736 surveys. The fewest detections occurred in the southwest Washington HCP Planning Units (Columbia and South Coast) where 1,124 detections were recorded on 6 percent of 3,332 surveys.

Other Threatened, Endangered, and Sensitive Species

Appendix D, Table D-11 lists the threatened, endangered, and sensitive species that are known or suspected to occur on DNR-managed forested trust lands. This table identifies each species' state and federal listing status, and the habitats with which it is associated.

DNR procedures provide specific direction for the management of habitat for species of interest, including threatened, endangered, and sensitive species (see Appendix C).

Deer and Elk

As noted above, black-tailed deer and Roosevelt elk are game species of cultural significance to tribal and other hunters, and are also valuable prey species for wolves and other large predators. As large and mobile animals, deer and elk can use different habitat elements in different forest types. Open habitats (e.g., ecosystem initiation forest) often provide foraging opportunities for these species. Studies in northwestern Washington have found that elk use thinned stands more than clearcuts for foraging. Closed-canopy forest may provide seclusion from human harassment (Cook et al. 1998). Both forage areas and cover can be provided by structurally complex forests. Understory vegetation provides forage while older trees in the overstory provide substrates for lichen production, decrease on-the-ground snow accumulation, and are sources of cover (Carey et al. 1996).

Habitat suitability models for deer and elk in western Washington and Oregon consider many factors, including quality of cover habitat, size and spacing of forage and cover areas, and road density (Witmer and deCalesta 1985; Wisdom et al. 1986). While an assessment of impacts to all the factors that contribute to habitat effectiveness for deer and elk is beyond the scope of this programmatic assessment, it is possible to indirectly address one key factor—size and spacing of forage and cover—by examining the proportion of forage habitat on the landscape.

Several studies of deer and elk have noted a decreased use of forage habitat when it is farther away from cover (Wisdom et al. 1986). As the proportion of forage habitat in a given area increases above 50 percent, the amount of forage in proximity to effective cover habitat will by necessity decrease. On the other hand, inadequate forage also reduces the capability of an area to support deer and elk. In areas managed for timber production, the Washington State Department of Fish and Wildlife has recommended that 30 to 60 percent of the landscape should consist of forage habitat (WDFW 1996). Data available for this analysis can be analyzed at three scales: all western Washington forested state trust lands, the five Westside HCP Planning Units and the Olympic Experimental State Forest, and watersheds. Of these, watersheds provide a suitable landscape scale for DNR to analyze foraging habitat, because they come closest to matching the area over which deer and elk may range during a season (Jenkins and Starkey 1990).

For this analysis, watersheds in which 30 to 60 percent of the forested area consists of structurally complex forest (i.e., the botanically diverse, niche development stage, and fully functional stages), and the ecosystem initiation stage, are considered to provide suitable habitat for deer and elk. While these forest stand development stages all provide forage, there are nutritional quality and quantity differences between ecosystem initiation and more structurally complex forest stages. Structurally complex forests provide higher quality forage than ecosystem initiation areas (Hanley et al. 1989).

The results from the Washington Forest Landscape Management Project (Carey et al. 1996) indicated that the estimated carrying capacities for deer and elk are comparable when either timber production is maximized or when 30 percent of the watershed is maintained in a fully functional forest stage. Currently, there are 144 watersheds in which foraging habitat makes up 30 to 60 percent of forested trust lands (Table 4.4-2). This amounts to 44 percent of the 324 western Washington forested state trust land watersheds. Estimated proportions of western Washington forested state trust lands composed of structurally complex forest increase over time under all Alternatives (Table D-14 in Appendix D), ranging from 29 percent under the Preferred Alternative to 23 percent under Alternative 5.

Table 4.4-2. Number of Watersheds[1/] Supporting Percentages of Deer and Elk Foraging Habitat Among Westside HCP Planning Units

	Number of Watersheds						
Percentage of Foraging Habitat[2/]	**Columbia**	**N. Puget**	**OESF[3/]**	**S. Coast**	**S. Puget**	**Straits**	**Total**
≤30% Forage	39	37	9	37	13	7	**142**
30%-60% Forage	20	50	20	12	22	20	**144**
>60% Forage	7	13	2	5	11	0	**38**
Total	**66**	**100**	**31**	**54**	**46**	**27**	**324**
Percent in 30%-60% range	30%	50%	65%	22%	48%	74%	**44%**

Data Source: Model output data – stand development stages.

1/ The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations, and percent totals are based on the total acres of forested trust land per WAU.

2/ Forest development stages that provide deer and elk forage include structurally complex forest (i.e., botanically diverse, niche development stage, and fully functional stage), and ecosystem initiation.

3/ OESF = Olympic Experimental State Forest

4.4.4 Environmental Effects

Changes to policies, procedures, and management intensities proposed in the Alternatives would be expected to affect wildlife species and the habitats with which they are associated. Effects of proposed changes in the policies and procedures that govern timber harvest and the protection of riparian and wetland areas are described in Sections 4.2, 4.3, and 4.9, respectively. The subsections below describe the potential effects on wildlife anticipated from the revisions to DNR policies and procedures, and from changes in harvest levels proposed in the Alternatives.

The Forest Resource Plan and the Habitat Conservation Plan (HCP) are two documents that help establish the goals and objectives for DNR management of forested trust lands. The proposed Alternatives represent various means of achieving these ends. Based on the extent and type of timber harvest proposed under the Alternatives, some Alternatives may achieve the desired goals sooner or later than others.

4.4.4.1 Habitats

This section addresses changes in the amount or quality of the five general wildlife habitat types under each Alternative, and how such changes may affect wildlife species associated with these habitats. Changes in the relative amount of forested habitat types are a product of varying rates and intensities of timber harvest under the different Alternatives. Appendix D, Table D-12 presents the modeled proportion of western Washington forested state trust lands comprising ecosystem initiation, competitive exclusion, and structurally complex forests under each Alternative in the years 2013 (short term) and 2067 (long term).

The acreage and location of riparian and wetland areas and uncommon habitats are not expected to change under any of the Alternatives, but the quality of the habitat provided by these areas would be expected to vary as a result of different amounts of harvest activity and intensity.

Ecosystem Initiation Forest Habitat

In a managed forest landscape, the amount of ecosystem initiation forest habitat depends primarily on the amount and intensity of regeneration harvest activity. Alternatives with higher levels of regeneration harvest would produce greater amounts of ecosystem initiation forest. Conversely, Alternatives with lower acreages of regeneration harvest would result in less of this habitat type, as less area would be harvested in any given time period.

This trend is evident in the model output for the six Alternatives. In both the short term and the long term, the amount of ecosystem initiation forest expected under Alternative 1 (No Action), and Alternative 4 would remain slightly below the levels expected under the other Alternatives (Figure 4.4-3, Appendix D, Table D-12). In both the short term and the long term, the greatest amount of this habitat type would occur under Alternative 5, under which the greatest amount of high-intensity harvest would be expected to occur. In the short-term, the Preferred Alternative would generate similar levels as Alternative 5 (13 percent versus 12 percent), but level off to at or below levels under Alternative 5 in the long term.

Overall, all six Alternatives would result in similar amounts of ecosystem initiation forest in both time frames, and no significant difference would be expected among the effects of the Alternatives on wildlife species associated with this forest type. This may not hold true within certain HCP Planning Units in some time periods. For example, model results for Alternative 4 suggest that 28 percent of the Straits HCP Planning Unit under general management objectives would consist of this habitat type in 2013, whereas Alternatives 2 and 3 would consist of 16 and 18 percent, respectively. Alternatives 5 and the Preferred Alternative results predict that more than 25 percent of the Straits Planning HCP Unit would consist of ecosystem initiation forest in 2013 (Appendix D, Table D-8).

No strict thresholds have been identified for an acceptable amount of ecosystem initiation forest habitat in a given landscape. However, elevated amounts of this habitat type indicate an increased potential risk of habitat fragmentation among closed-canopy forest types (e.g., structurally complex).

Carey et al. (1996) note that some forest bird species reach their greatest abundance and diversity in forest stages with high shrub cover, particularly ecosystem initiation forest. Long-term increases in the amount of ecosystem initiation forest on the landscape would likely result in localized increases in populations of these species. This would occur with corresponding decreases in the amount of competitive exclusion forest, which is characterized by low abundance and diversity among these species. Deer and elk would also be expected to benefit from the increased availability of foraging habitat in proximity to competitive exclusion and structurally complex forest (both of which provide cover).

Competitive Exclusion Stages

Forest in the competitive exclusion stages is currently the most abundant habitat type on DNR-managed forested trust lands. Under all Alternatives, the majority of timber harvest is expected to occur in this habitat type. Two processes would likely affect the amount of competitive exclusion forest: conversion to ecosystem initiation forest through high-volume timber harvest, and development into structurally complex forest through natural forest succession and forest management activities such as thinning.

Model output data indicate that the amount of competitive exclusion forest on forested trust lands would decline under all six Alternatives in both the short term and the long term (Figure 4.4-3). In the short term, results show very little difference in the amount of competitive exclusion forest among the Alternatives (Appendix D, Table D-12). Model outputs indicated that at the end of the planning period (by 2067), all Alternatives would reduce the amount of forestlands in competitive exclusion. Under Alternatives 1, 4, and 5, approximately 65 percent of forested trust lands would consist of competitive exclusion forest, while Alternatives 2 and 3 would result in about 64 percent. Under the Preferred Alternative, 60 percent of the forested trust lands would consist of competitive exclusion forest (Appendix D, Table D-12).

For the most part, decreases in the amount of competitive exclusion forest correspond to increases in the amount of structurally complex forest. This result suggests that many areas that currently sustain competitive exclusion forest would acquire the characteristics of structurally complex forest over time. The greatest long-term declines in competitive exclusion forest would likely occur under the Preferred Alternative, followed in descending order by Alternatives 1, 4, and 5, and then 2 and 3.

The change in these closed-canopy competitive exclusion forest stands into more diverse, structurally complex forests would occur only as the canopy opens up. The tree canopy of a forest stand opens as a tall tree or some smaller trees die, or as a tree gets taller and allows sunlight to reach the forest floor below its high branches. Trees in the canopy and sub-canopy die for a number of reasons. The principal reasons include lack of nutrient and light resources due to competition among trees, and natural disturbances such as wind, fire, insects, and disease.

Declines in the amount of competitive exclusion forest would not be expected to result in any significant adverse effects to wildlife species overall. No wildlife species are found exclusively in competitive exclusion forests, and decreases in the amount of competitive exclusion forest would nearly be matched by increases in structurally complex forest.

Additionally, retrospective studies of vertebrate communities in intensively managed commercial forests (e.g., Aubry et al. 1997) and natural forests (e.g., Ruggiero et al. 1991) show broadly similar species lists. Thus, no wildlife species would be expected to experience habitat reductions, and overall wildlife diversity may increase with the increased amounts of forest habitat types that generally support greater abundance and diversity of wildlife species (ecosystem initiation and structurally complex) (Carey et al. 1996).

Structurally Complex Forest

In the short term, changes in the amount of structurally complex forest under all Alternatives would largely be the result of different levels of management intensity. Alternatives with more high-volume timber harvests (i.e., Alternative 5) would be expected to result in less of this habitat type than those with more areas deferred from harvest (Alternative 1), or those with longer rotation lengths (Alternative 4). Under the latter two Alternatives, in any given time period, fewer structurally complex stands would be subject to regeneration harvest. These Alternatives, therefore, would show greater acreage of complex forest relative to an Alternative that emphasizes intensive regeneration harvest.

In the long term, the amount of structurally complex forest would also depend on the forests' growth and development, which would in turn be influenced by their harvest history. For example, competitive exclusion stands that have been heavily thinned can be expected to acquire the characteristics of structurally complex forest sooner than those that are left alone (Carey et al. 1996; Thysell and Carey 2000). Also see Chapter 2, Section 2.6.3.4 for additional discussion on thinning levels and multi-canopy development over time.

Model output supports the concept that heavier thinning (i.e., over 50 percent of the basal area) would promote the development of structurally complex forest that provide snag and down wood levels associated with fully functional forests. It is worthwhile to emphasize that the model will not control actual stand prescriptions; on-the-ground evaluation of the stand will determine the appropriate thinning strategy with no presumption that it will be 50 percent of the basal area or any other default number. In both the short term and the long term, the Preferred Alternative results in the greatest amount of structurally complex forest on forested trust lands (Figure 4.4-3, and Appendix D, Table D-12). All other Alternatives also result in net increases in both the short term and the long term, but to a lesser degree. Alternative 5 exhibits the smallest increases in both time periods.

For the most part, this overall pattern is repeated at the individual HCP Planning Unit scale. The main exception is the South Puget HCP Planning Unit, where among the proposed Alternatives, the Preferred Alternative appears to yield some of the greatest increases in structurally complex forest in the long term. The Preferred Alternative also proposes the most acres of timber harvest in the South Puget HCP Planning Unit, as well as the greatest decline in competitive exclusion forest.

These findings suggest that a biodiversity pathway management approach appears to be compatible with maximizing the amount of structurally complex forest, at least in some areas. Alternative 5 proposes more traditional thinning prescriptions and appears to yield the second-highest harvest levels in the South Puget HCP Planning Unit. However, it appears Alternative 5 would result in the smallest increases in structurally complex forest in this unit in almost all time periods. For a discussion of changes in the amount of structurally complex forest in the Olympic Experimental State Forest under the six Alternatives, see the analysis of northern spotted owl nesting, roosting, and foraging habitat availability in Section 4.4.4.2 below.

Based on model outputs, actively managed stands appear to result in the greatest increases in fully functional forest stages, or those characterized by the highest amounts of snags and downed trees. Alternatives 1 and 4 closely follow the Preferred Alternative in providing structurally complex forest. However, an examination of the two stand development stages that are characterized by abundant woody debris (niche diversification, and fully functional), shows the Preferred Alternative to exceed Alternatives 1 and 4 in developing these complex forests. It therefore appears that the biodiversity pathway techniques employed by the Preferred Alternative would likely provide improvements in forest diversity comparable to a more “hands-off” approach, while increasing timber flow from forested trust lands (see Figure 4.2-2, and Appendix D, Table D-12).

Riparian and Wetland Habitats

Effects to species associated with riparian habitats under the different Alternatives would result from timber harvest activities in Riparian Management Zones and from changes in riparian habitat conditions. Increased levels of harvest activity in the riparian areas increase the potential for disturbing wildlife species that use these areas, and of altering habitat features upon which they depend. Active management can also accelerate the rate at which a stand reaches structurally complex forest stages. Short-term impacts are to be considered with the understanding of long-term benefits. Over time, development of structurally complex forest dominated by large trees improves the ability of riparian areas to play a vital role in the health of stream ecosystems and terrestrial ecosystems.

Section 4.3, Riparian Areas, presents the effects of forest management activities on riparian areas under the six Alternatives. During the remaining period of the Habitat Conservation Plan (HCP), Alternatives with lower levels of activity, such as Alternatives 1 through 4, are expected to have a higher proportion of riparian area with large and very large trees that are in competitive exclusion stages. In contrast, Alternatives with higher levels of active management, such as the Preferred Alternative, are expected to have more riparian area that will be fully functioning, or be on a trajectory towards full function. Regardless, riparian conditions are expected to improve under all Alternatives relative to current conditions. This is due to changes in stand structure, particularly increases in the amount of stand development stages that include large and very large trees, which are in moderate supply throughout much of the western Washington forested state trust lands (see Figure 4.3-2). Within riparian areas, the rate of improvement in structurally complex forests overall is similar among the Alternatives. However, active management under the Preferred Alternative is expected to achieve fully functioning stands within 80 to 90 years, rather than approximately 220 years under passive techniques (Carey et al. 1996).

Over the short term (i.e., the next decade of the HCP), little difference is expected in the distribution of stand development stages among the six Alternatives (Figure 4.3-2). The proportion of Riparian land class in stand development stages that include large and very large trees is expected to increase from about 57 percent to 62 or 63 percent, with the vast majority of this increase expected in the large tree exclusion and understory development stages. The amount of stages with very large trees is expected to remain at about 25 to 26 percent of the Riparian land class because increased growth expected from stand manipulations would take some time to become fully expressed, and only a small percentage of riparian areas would be treated in the first decade (up to about 4.5 percent of the riparian area).

Differences among the Alternatives are expected to become more substantive over the long term (Figure 4.3-2). The proportion of the Riparian land class with large tree and very large tree is expected to increase over current conditions from about 57 percent under current conditions to 78 percent to 90 percent of the Riparian land class, depending upon the Alternative (Figure 4.3-2). Alternatives 1 and 4 are expected to have the highest amount, with about 90 percent of the Riparian land class in these stages. Alternatives 2, 3, and 5 are expected to have about 82 to 83 percent of the Riparian land class. The Preferred Alternative is expected to have the lowest proportion of the Alternatives, with about 78 percent of the Riparian land class that contain large and very large trees (Figure 4.3-2).

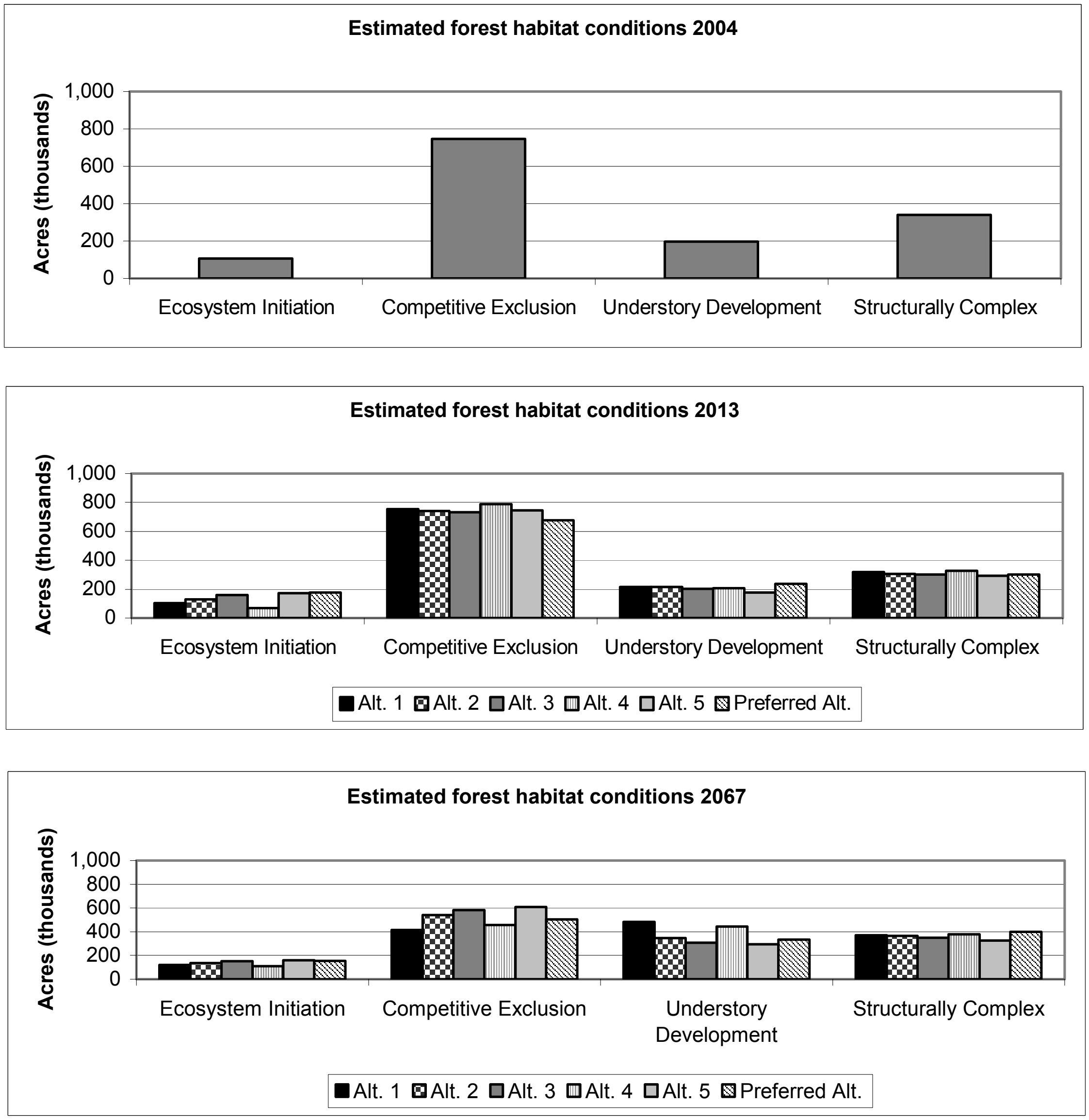

Figure 4.4-3. Current (2004) and Estimated Future Amounts of Forested Habitat Types on Forested Trust Lands under Each Alternative

Although the Preferred Alternative is expected to have the lowest proportion of stand development stages that include large and very large trees modeled as competitive exclusion, it is also expected to have the highest proportion of the most complex classes of niche diversification and fully functioning stand development stages. These two stand development stages will each comprise about 6 to 7 percent of the Riparian land class. In contrast, Alternatives 1 to 4 are expected to have about 4 percent and 3 percent of the Riparian land class in niche diversification and fully functioning stages, respectively, and Alternative 5 is expected to have about 2 percent in each (Figure 4.3-2). The modeling results support the qualitative assessment that under the Preferred Alternative, active management of stands in competitive exclusion stages helps to move stands towards development pathways that more rapidly lead to a fully functional stand structural state compared to more passive management.

Although the Preferred Alternative would be expected to result in the least amount of area with very large trees, this Alternative would likely result in a slightly higher amount (13 percent) of Riparian land class area in fully functional or niche diversification forest stand development stages compared to the other Alternatives. Alternative 5 would be expected to result in the lowest amount (approximately 4 percent) (Figure 4.3-3). The major added feature that distinguishes the fully functional and niche diversification development stages from other multi-canopy stages with very large trees is the presence of higher levels of decadence, such as snags, down coarse woody debris, and epiphytes. Consequently, over the long term, the more intensive biodiversity pathways approach proposed in the Preferred Alternative would likely yield higher riparian function on more of the Riparian land class than Alternatives 1 to 5, but with the trade-off of having potentially less area with large trees in the Riparian land class in the short to mid term. Areas with very large trees would likely achieve full function eventually over time. However, given stand densities within riparian areas and the level of natural or managed disturbance needed for succession through the development stages, Alternatives 1 to 5 may take a very long time to produce substantial amounts of fully functioning riparian forests.

Effects to species associated with wetland habitats would largely depend on changes in the ability of those areas to provide suitable habitat. Changes in water quality or hydrologic regime, for instance, may have negative effects on amphibian species that use wetlands for breeding. Loss of water during spring and summer, when eggs are laid and larvae develop, may eliminate some species from a particular site. On the other hand, a change to year-round standing water may allow the introduction of predators and competitors such as bullfrogs and fish. However, given that the site-specific policy objectives (no net loss of wetlands and protection of wetland functions) control individual silvicultural activities, it is not likely that there would be a material effect on wetland functions.

Section 4.9, Wetlands, addresses the effects of forest management on wetlands and the potential for the Alternatives to affect wetland quality. This discussion is summarized below. The difference in environmental effects to wetlands under all Alternatives would be a function of both the acres of trees harvested and the amount of related activities.

Under all Alternatives, non-forested wetlands would be protected with a no-harvest buffer. Timber harvest in surrounding forests may indirectly affect adjacent habitats by changing microclimatic conditions such as temperature, light, and hydrologic regimes. Some disturbance, localized clearing or loss of wetland acreage, may also occur (though no net loss of wetlands would occur per Forest Resource Plan Policy No. 21). In contrast, thinning (down to 120 square feet of basal area) would be allowed in forested wetlands under all of the Alternatives. Alternatives that result in a proportionally greater amount of harvest within the Riparian land class would have a greater potential for effects to forested wetlands that occur within Riparian Management Zone boundaries.

Table 4.9-1 provides a summary of the average harvest by decade in the riparian and wetland areas for each Alternative. In riparian and wetland areas, Alternative 1 has the lowest level of activities, with an average of about 2 percent of acres disturbed per decade. Therefore, Alternative 1 would have the lowest potential to affect wetlands and riparian areas. This is followed by Alternative 2 with 4 percent per decade, Alternatives 3 and 4 with 5 percent, and Alternative 5 with 7 percent. The Preferred Alternative would have the highest level of harvest-related activities in riparian areas, with an average of 8 percent of acres disturbed per decade, the result of thinning to develop structurally diverse stands. Therefore, the Preferred Alternative would have the highest potential to affect wetlands and riparian areas, followed closely by Alternative 5.

Uncommon Habitats

Under all Action Alternatives, legacy and reserve tree requirements in DNR Procedure 14-006-090 would be replaced with language implementing the protection of large structurally unique trees and snags described in the Habitat Conservation Plan (HCP). The current administrative requirement to retain 7 percent of the pre-harvest trees per acre would remain in place under Alternative 1 (No Action), and would be changed to the HCP's requirement of at least eight trees per acre under the other Alternatives. Procedure 14-006-090 addresses retention of legacy trees in regeneration harvest areas. Thus, although Alternatives 2 through the Preferred Alternative may marginally reduce the number of legacy trees that would be retained in regeneration harvest (assuming most stands selected for regeneration harvest have approximately 120 trees per acre greater than 12 inches diameter at breast height, the size specified in Procedure 14-006-090), they would be expected to result in a similar number of legacy tree retention overall. The Action Alternatives would pose no significant environmental impacts beyond existing conditions and those anticipated in the HCP Environmental Impact Statement (EIS). Further, the proposed change authorizes field foresters to adjust the numbers upwards to reflect local needs.

Retention of biological legacies (snags, down trees, and other woody debris) is an essential component of a management program designed to accelerate forest ecosystem development (Carey et al. 1996). Increased retention of legacy trees would be expected to increase habitat availability for many wildlife species (e.g., marbled murrelet, northern spotted owls, a number of bat species, and cavity-nesting birds such as pileated woodpecker and Vaux's swift) and help accelerate the rate at which structurally complex forest would develop in the planning area.

Of the other uncommon habitats addressed in this analysis, most are non-forested areas such as cliffs, caves, talus fields, and balds (grass- or moss-dominated forest openings), the amount of which is not expected to change in response to timber harvest activities. Oak woodlands are also considered uncommon habitats. The native Oregon white oak is considered a non-commercial tree species, and as such is not included in timber harvest calculations under any of the Alternatives. Effects to uncommon habitats may occur, however, as a result of logging in adjacent commercial forest stands.

DNR procedures provide direction for protecting these habitats where they have been identified. Not all areas have been identified, however, and small patches (e.g., talus patches less than 1 acre, cliffs less than 25 feet high) receive no specific protection. Timber harvest in adjacent stands, therefore, carries the potential risk that personnel or equipment may damage these habitats, or disturb species that rely on them. Timber harvest may also indirectly affect adjacent habitats by changing microclimatic conditions such as temperature, light, and water movement. Road construction may also harm these habitats, although procedures direct DNR to avoid road construction through talus fields and balds where practicable.

The amount of timber harvest anticipated under each Alternative serves as an indicator of the relative risk of potential adverse effects to uncommon habitats. A higher rate of harvest suggests a greater potential risk of damage or disturbance to these habitats and associated species. Table D-4 (Appendix D) summarizes the average harvest per decade under each Alternative. Overall, the greatest area of harvest is anticipated under Alternative 5, followed in descending order by Alternatives 3, 2, 4, the Preferred Alternative, and Alternative 1. The amount of road construction is expected to be similar under all Alternatives. Though different levels of harvest are anticipated on lands adjacent to those containing uncommon habitats, no significant environmental effects beyond those described in the HCP EIS are anticipated under any of the Alternatives when compared with Alternative 1 (No Action).

4.4.4.2 Species of Interest

Northern Spotted Owl

None of the Alternatives, including the Preferred Alternative, propose changes to the northern spotted owl conservation strategy, as outlined in the Habitat Conservation Plan (HCP) on pages IV.1 to IV.19 and IV.86 to IV.106 (DNR 1997). The HCP Environmental Impact Statement (EIS) is incorporated by reference (DNR 1996) and relied on in this Final EIS. In addition, this Final EIS analyzes the Alternatives in light of the new information on northern spotted owl demography discussed in Section 4.4.3 of this chapter. The analysis also includes a comparison of the Alternatives using three criteria:

- changes in the amount of structurally complex forest;
- the amount of timber harvest in areas designated as Nesting, Roosting, and Foraging Management Areas and Dispersal Management Areas; and
- changes in the management of northern spotted owl circles.

Based on this analysis, none of the Alternatives is expected to have significant adverse impacts that were not already evaluated in the HCP EIS and agreed to by the Federal Services.

CHANGES IN THE AMOUNT OF NESTING, ROOSTING, FORAGING, AND DISPERSAL HABITAT

As noted above, for this analysis, forested areas classified as structurally complex forest serve as an indicator for nesting, roosting, foraging, and dispersal habitat. A qualitative discussion of the potential for the Alternatives to affect the amount and distribution of structurally complex forest among the Habitat Conservation Plan (HCP) Planning Units is presented in Section 4.4.4.1 above.

Alternatives with less intensive timber harvest would be expected to result in marginally greater amounts of structurally complex forest in the short term, because comparatively few areas that currently provide structurally complex forest would be subject to heavy thinning or regeneration harvest. Results indicate that Alternative 1 (No Action) and Alternative 4 would result in slightly greater overall increases in the amount of structurally complex forest in the short term; however, the Preferred Alternative would produce more structurally complex forest beginning in 2031, particularly in the niche diversification and fully functional stand development stages (see Appendix D, Table D-12). Alternative 5 would result in the smallest short- and long-term increases.

The amount of structurally complex forest in the Olympic Experimental State Forest merits particular attention because this HCP Planning Unit has different management strategies than the other HCP Planning Units. Modeled changes in the amount of structurally complex forest cannot be used to judge whether management goals have been met, but they do allow a comparison of the relative rates at which desired habitat may develop under each Alternative. Alternative 4 would result in the greatest short-term increases in the amount of structurally complex forest in the Olympic Experimental State Forest, exceeding 26 percent of that HCP Planning Unit by 2013. Alternative 5 would provide the fewest number of acres during the same time period with 18 percent of the land base in structurally complex forest. The greatest long-term gains are modeled for Alternative 4, under which structurally complex forest would exceed 29 percent of the area of the Olympic Experimental State Forest by 2067. Alternatives 1, 2, and 3 would produce similar long-term gains at approximately 28 percent, followed by the Preferred Alternative with about 27 percent. Alternative 5 would produce the least amount of structurally complex forest by 2067, with about 16 percent of the Olympic Experimental State Forest HCP Planning Unit (Appendix D, Table D-8).

In Nesting, Roosting, and Foraging Management Areas and Dispersal Management Areas, intensive management under the biodiversity pathway approach of the Preferred Alternative would also be expected to result in long-term increases in structurally complex forest. Model results support this expectation. While the six Alternatives differ only slightly in the amount of structurally complex forest in Nesting, Roosting, and Foraging Management Areas in the short term, long-term increases modeled for the Preferred Alternative surpass all other Alternatives (Table 4.4-3). The less-intensive approaches of Alternatives 1 (excluding more areas from timber harvest) and 4 (managing for longer rotation lengths) would result in slightly smaller increases than the Preferred Alternative. Compared to Alternatives 1 and 4, however, the Preferred Alternative would result in

Table 4.4-3. Acres of Structurally Complex Forests in Designated Nesting, Roosting, Foraging, and Dispersal Management Areas in 2067

	Current Conditions	Alternative					
		1	2	3	4	5	PA
Nesting, Roosting, and Foraging Habitat Areas	53,816	60,218	55,603	55,144	58,158	53,706	64,420
Dispersal Habitat Areas	30,578	30,857	29,262	28,414	32,335	27,694	40,244

Data Source: Model output data – standard development stages.
PA = Preferred Alternative

approximately twice as much niche diversification and fully functional forest stages, the most complex two stand development stages, in designated Nesting, Roosting, and Foraging Management Areas.

In comparison to nesting, roosting, and foraging habitat, dispersal habitat would increase compared to current conditions only under the Preferred Alternative and Alternatives 1 and 4. The development of structurally complex forest in areas that receive little or no timber harvest would be expected to be higher than those Alternatives with more harvest; however, model results indicate that the Preferred Alternative would provide nearly twice as much nesting, roosting, and foraging habitat compared to the other Alternatives. Therefore, biodiversity pathway approaches within Dispersal Management Areas appear to provide higher quality habitat over a larger area (Nesting, Roosting, and Foraging Management Areas and Dispersal Management Areas), with a relative increase of 18 percent over the long term (Appendix D, Table D-13).

All six Alternatives would result in a slight short-term decrease in the availability of structurally complex forest within designated Nesting, Roosting, and Foraging Management Areas ranging from 3 percent to 11 percent; however, in the long term, all provide increases except for Alternative 5 (Appendix D, Table D-13). Differences among the Alternatives are small in the short term, ranging from a reduction of 5 to 11 percent.

Alternatives 1 and 4 show decreases of 6 and 5 percent, respectfully, while Alternatives 2, 3, and the Preferred Alternative show reductions of 10 to 11 percent. The Preferred Alternative is the only Alternative that shows an increase, beginning in 2031.

Timber Harvest in Areas Designated as Nesting, Roosting, and Foraging Management Areas

None of the Alternatives would allow activities that would reduce the amount of nesting, roosting, and foraging habitat in below-threshold watersheds. Alternative 1 would be expected to result in the lowest levels of harvest activities in designated Nesting, Roosting, and Foraging Management Areas, and Alternative 5 the most. Model results support this expectation (Table 4.4-4). Alternative 5 would result in the highest level of forest management activity in areas designated as Nesting, Roosting, and Foraging Management Areas, with an average of 16 percent of such areas harvested per decade. Under all of the

Table 4.4-4. Average Percent of Designated Nesting, Roosting, and Foraging Management Areas Harvested under Each Alternative per Decade at Various Harvest Volume Classes, Compared to the Average Harvest Rate in All Areas

Alternative	Average Percent of Designated Nesting, Roosting, and Foraging Management Areas by Area Impacted per Decade by Harvest Type				Average Percent of Total Forested Trust Lands Harvested per Decade
	Volume Removal Class				
	Low-Volume Removal Harvest[1/]	Medium-Volume Removal Harvest[2/]	High-Volume Removal Harvest[3/]	Total	
1	0%	0%	1%	**1%**	11%
2	3%	2%	7%	**12%**	16%
3	2%	0%	8%	**10%**	17%
4	3%	2%	3%	**8%**	15%
5	7%	2%	7%	**16%**	24%
PA	1%	2%	8%	**11%**	14%

Data Source: Model output data – timber flow levels.
1/ Less than 11 thousand board feet per acre volume harvests
2/ Between 11 and 20 thousand board feet per acre volume harvests
3/ Greater than 20 thousand board feet per acre volume harvests
PA = Preferred Alternative

Alternatives, designated Nesting, Roosting, and Foraging Management Areas would be harvested at a lower rate than the rate for all lands. Alternative 1 is expected to have the least harvest in designated Nesting, Roosting, and Foraging Management Areas.

Alternative 4, with an older average minimum regeneration age and a relatively low rate of harvest overall, results in the second lowest harvest rate in designated Nesting, Roosting, and Foraging Management Areas. Alternatives 2 and 3 result in similar moderate amounts, and Alternative 2 is exceeded only by Alternative 5.

The greatest amount of high-volume removal harvest activity in designated Nesting, Roosting, and Foraging Management Areas would occur under Alternatives 3 and the Preferred Alternative, followed (in descending order) very closely by Alternatives 2 and 5. Alternatives 4 and 1 have the lowest levels of high-volume removal harvests in Nesting, Roosting, and Foraging Management Areas. Notably, the majority of harvest in designated Nesting, Roosting, and Foraging Management Areas under the Preferred Alternative consist of biodiversity thinnings, and would, therefore, be designed to improve habitat conditions, and increase the potential of a stand to becoming nesting, roosting, and foraging habitat sooner.

EFFECTS TO NORTHERN SPOTTED OWL CIRCLES OUTSIDE NESTING, ROOSTING, AND FORAGING, AND DISPERSAL MANAGEMENT AREAS

Under all six Alternatives, habitat within "Memorandum #1" northern spotted owl circles would be released in 2007 for timber harvest consistent with the objectives and strategies of the Habitat Conservation Plan (HCP). This represents no policy change because Memorandum #1 would have released these circles in 2007 (the end of the first decade of implementation of the HCP). Status 1 reproductive circles outside the Olympic Experimental State Forest would also be released in 2007 under Alternatives 3 through 5 and the Preferred Alternative, and would be released in 2004 under Alternative 2. Status 1 reproductive circles in the Olympic Experimental State Forest are not deferred under any of the Alternatives except the No Action. The four northern spotted owl circles in southwest Washington will be released in 2006 under all Alternatives except the No Action. Under Alternative 1 (No Action), timber harvest deferrals in Status 1 reproductive and southwest Washington circles are modeled as long-term deferrals. DNR and the Washington State Department of Fish and Wildlife developed an agreement for managing harvest activities in the four southwest Washington circles. This agreement is scheduled to remain in effect until 2006.

The release of northern spotted owl circles from the various administrative restrictions in 2007 (as it is assumed by the Preferred Alternative) will not automatically result in harvest of all suitable northern spotted owl habitat. Out of the entire area of the northern spotted owl circles that overlap with forested trust lands in the five Westside HCP Planning Units and the Olympic Experimental State Forest (296,200 acres):

1. DNR would entirely protect about 83,200 acres as part of the long-term deferral. This means they would not be harvested over the term of the HCP.
2. Out of the remaining 213,000 acres that are not deferred, 74,000 acres would be under restrictions that apply to riparian zones and wetlands, and 94,300 acres would be under restrictions that apply to Uplands with Specific Objectives (e.g., Nesting, Roosting, Foraging, and Dispersal Management Areas, unstable slopes, etc.). These restrictions would result in full or partial retention of northern spotted owl habitat.

Therefore, approximately 44,700 acres within the released northern spotted owl circles would be available for regeneration harvest once the above-mentioned northern spotted owl circles are released (Figure 4.4-4). The general harvest restrictions apply for these acres (leave trees retention, wind buffers, etc.).

Consequently, DNR is currently far below the level of harvest that was anticipated by the 1997 HCP for the first decade of its implementation. Cumulatively, through 2007, harvest levels will be lower than the levels evaluated in the HCP Biological Opinion.

WORST-CASE ANALYSIS – NORTHERN SPOTTED OWL

The Habitat Conservation Plan (HCP) Draft Environmental Impact Statement (EIS) analyses conducted in 1996 used two main variables to assess the level of take and to project the future recovery of the subspecies on forested trust lands—the annual population rate of change and the extent of improvement of owl habitat on federal lands. The initial expectations in the HCP and the Northwest Forest Plan were that the northern spotted owl populations would decline during the initial decades of the each plan's implementation, after which the populations would eventually stabilize at a new equilibrium level as the

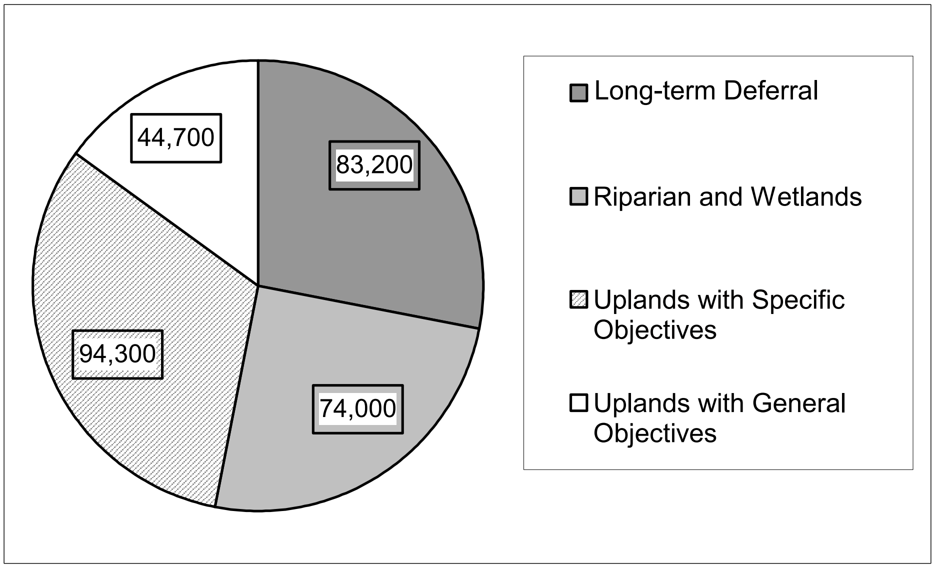

Figure 4.4-4. Projected Distribution of the Forested Trust Lands by Land Class and Deferral within Owl Circles that Would be Released from Protection Prior to 2007

habitat in northern spotted owl conservation areas developed. The most recent information on the northern spotted owl population trends (Anthony et al. 2004) shows a more accelerated decline in population numbers in the state of Washington than expected. At the same time, there is no consensus among the scientists about the major causes of this accelerated decline, and there are no data on the exact degree of northern spotted owl habitat improvement on federal lands.

Thus, the question in light of this worse-than-expected population decline is whether the Alternatives remain within the range of impacts previously studied when the DNR adopted

its HCP, and if not, what additional impacts may result from the Alternatives. Resolving this question with scientific certainty is not possible, due to the lack of information about the causes of the accelerated decline and the status of northern spotted owl habitat on federal lands. It is not possible for DNR to obtain the information that may solve the existing scientific uncertainty because:

1. The analysis of the causes of population decline could not be conducted solely by DNR because of the small segment of the population occurring on forested trust lands. This type of analysis should consider the entire population in Washington State and involve all land ownerships.

2. The data on the northern spotted owl habitat improvement on federal lands are supposed to be provided as part of the Northern Spotted Owl Effectiveness Monitoring Program for the Northwest Forest Plan (Lint et al. 1999). The habitat map development and evaluation has been initiated, but there are still no available results for the

Washington physiographic provinces (Lint et al. 2004). It is also not reasonable to wait for the release of the U.S. Fish and Wildlife Service 5-year review of the spotted owl status, which is scheduled for the end of 2004, because although it is expected to provide more information on the potential reasons for the population decline, it is unlikely that the report will analyze directly whether the relative significance of non-federal lands' contribution, and particularly the relative significance of DNR-managed forested trust lands to northern spotted owl conservation, has changed. This information would be relevant in determining whether the analysis in the HCP and its EIS remains an accurate assessment of environmental impacts to the northern spotted owl, in the face of the new information on the rate of population decline.

Because of the lack of sufficient information to allow us to assess the level of impacts of the Alternatives on the northern spotted owl, and following the requirements of the State Environmental Policy Act rules on dealing with scientific uncertainty, a worst-case analysis is presented below. The following elements of the worst-case scenario are analyzed individually in terms of likelihood to occur, and together for severity of the threat they represent today.

1. Assume that northern spotted owl habitat loss is the major cause of the northern spotted owl population decline.

This was the major threat in the past and the primary reason to list the subspecies in 1990. Currently, with the establishment of system of protected areas under the Northwest Forest Plan, the implementation of the Forest Practices rules, and the habitat protection provided by DNR's and several other HCPs, it is unlikely that this is the major reason for population decline. However, limited habitat resulting from the aggressive harvests in 1970s and 1980s continues to be a significant problem.

Current studies on the barred owl invasion suggest that barred owls may be the major cause for the northern spotted owls' recent population decline (Gremel 2001, 2003; Forsman et al. 2003; Kelly et al. 2003; Lint et al. 2003; Pearson and Livezey 2003). In the last few years, barred owl detections have increased rapidly in the Pacific Northwest, with the major threat that barred owls may be out-competing northern spotted owls for limited resources (e.g., prey, habitat). Direct encounters and hybridization are considered relatively rare events (Hamer et al. 1994; Kelly et al. 2003) and therefore minor threats at this time. Pearson and Livezey (2003) stated that northern spotted owl site occupancy appeared to be more affected by the presence of barred owls than by land management allocations; however, they suspect that the human-caused loss of old forest might reduce the ability of northern spotted owls to compete successfully with barred owls.

2. Assume that the northern spotted owl habitat on federal lands did not improve in the last decade.

This is highly unlikely. According to the recent data from Bureau of Land Management and U.S. Fish and Wildlife Service (Bown 2004; Cadwell 2004), the amount of reserved land is greater than in 1994 and the federal timber harvest has been lower than anticipated in the Northwest Forest Plan. The percentage of habitat removal due to land management was 2.11 percent, and the removal due to natural disturbance was 3.03 percent for the period 1994 to 2003 (Bown 2004). Additionally, the U.S. Fish and Wildlife Service estimated that 600,000 acres of late-successional forest developed per decade, although this is not necessarily northern spotted owl habitat (Bown 2004).

The role of the federal lands is crucial for the persistence and recovery of the subspecies. Although the Recovery Plan for the Northern Spotted Owl recommended involvement of federal, state, and private sectors as the most effective approach, it placed strong emphasis on the need for appropriate federal land management as a basis for recovery (USDI 1992).

Even if the above worst-case scenarios proved to be true, the Alternatives proposed, including those that revise Procedure 14-004-120, are highly unlikely to have greater adverse impacts to northern spotted owl populations than those evaluated in the HCP. The forested trust lands currently support only the sink sub-populations, and are likely to continue to support only sink sub-populations at least into the next decade. Given the amount, quality, and fragmentation (primarily as a result of current DNR land ownership patterns) of northern spotted owl habitat on forested trust lands, it is reasonable to assume, that the recent northern spotted owl population trend on forested trust lands is similar to or worse than the trend on federal land (HCP Draft EIS, DNR 1996; data from the DNR internal annual monitoring reports for the Olympic Experimental State Forest and Eastside HCP Planning Units; personal communications from Scott Horton and Eric Forsman, for the Olympic Experimental State Forest and the Westside HCP Planning Units). DNR continues to have very limited ability to contribute to the demographic support for the northern spotted owl populations on federal lands. This is especially true for lands outside of Nesting, Roosting, Foraging, and Dispersal Management Areas under the HCP, where the DNR's HCP strategy was never to preserve individual northern spotted owl site centers that are long distances from federal lands. The primary means of providing demographic support continues to be through the Nesting, Roosting, Foraging, and Dispersal Management Area conservation commitments under the DNR's HCP.

The HCP Draft EIS concluded that the primary means of benefiting the northern spotted owl recovery would be through the development of sufficient amount and quality of nesting, roosting, foraging, and dispersal habitat in the designated habitat management areas. The removal of the northern spotted owl habitat *outside* the designated management areas was included in the analyses for take of northern spotted owls (HCP EIS, DNR 1996). The HCP's Biological Opinion (USDI 1997) assumed that all suitable habitat in the owl circles outside of the Nesting, Roosting, Foraging, and Dispersal Management Areas would be harvested within the first decade of the HCP. The severity of the threat as a result of harvesting outside designated northern spotted owl nesting, roosting, foraging, and dispersal habitat was assessed and accepted by the Federal Services. Risks associated with the loss of reproductive northern spotted owls outside those northern spotted owl management areas were considered acceptable in light of gains in long-term habitat availability; these risks were not anticipated to jeopardize the continued existence of northern spotted owls. Hence, the northern spotted owl circles outside Nesting, Roosting, and Foraging Management Areas and Dispersal Management Areas were not anticipated to contribute to the recovery of the species. Recently, facing the more rapid decline in population numbers on federal land and state lands, it is even less likely that they will provide demographic support because of the following reasons: 1) they are least likely to remain occupied compared to the larger contiguous blocks of protected habitat in the Nesting, Roosting, and Foraging Management Areas and the Dispersal Management Areas, and 2) the circles that remain occupied become even more isolated due to the decreased density of the northern spotted owl population.

The primary contribution of forested trust lands to the northern spotted owl conservation effort comes through the protection and/or development of suitable habitat in the designated Nesting, Roosting, and Foraging Management Areas and Dispersal Management Areas. The HCP has a landscape-level focus on population dynamics, rather than relying on the protection of individual northern spotted owls. Currently, the Nesting, Roosting, and Foraging Management Areas are most likely to also support only the sink sub-populations, because of the low numbers of northern spotted owls in these areas, and the fact that in most of the Nesting, Roosting, and Foraging Management Areas, the functional northern spotted owl habitat has not yet achieved the targeted levels. The Nesting, Roosting, and Foraging Management Areas are intended to provide demographic support to the federal populations in the long term (Biological Opinion, p.63).

Alternatives 1 and 4 consider only habitat enhancement activities in the non-habitat portion of the designated habitat. Alternatives 1 and 4 have a passive management approach whereby thinnings in the non-habitat portion are traditional, i.e. the thinnings typically remove smaller trees and leave approximately 70 percent of the stands after harvest (see Chapter 2, Section 2.6.3.4). This management would result in development of structurally complex forest through natural succession in the non-habitat portion. It would also result in stands remaining in the competitive exclusion stage longer in the non-habitat portion. Alternative 4 is very similar, with the exception of proposed longer rotations in the non-habitat portion that would result in older but still even-aged stands. Alternatives 2, 3, and 5 would implement more harvest activities in the non-habitat portion, meaning they include traditional thinnings and regeneration harvests. The Preferred Alternative includes a management approach for designated Nesting, Roosting, and Foraging Management Areas and Dispersal Management Areas in the form of variable density thinnings in alternating rotations of 100 to 140 and 50 to 70 years (see Chapter 2, Section 2.6.3.4). In the long term, this would result in significantly greater amounts of structurally complex forest than would result from passive management (see Table 4.4-3). Even though the structurally complex forest does not directly correspond to nesting, roosting, and foraging habitat, the increase correlates to the amount and quality of nesting, roosting, foraging, and dispersal habitat. Consequently, this type of management would have the most positive influence on the creation of functional nesting, roosting, foraging, and dispersal habitat in the designated management areas, and thus be most beneficial to the northern spotted owl conservation in the long term.

Marbled Murrelet

The analyses for the Final Environmental Impact Statement (EIS) do not attempt to assess site-specific management, but rather are designed to support broad policy level decision-making for western Washington by Habitat Conservation Plan (HCP) Planning Unit. Table B.2.6-1 in Appendix B lists the land deferrals for marbled murrelet management; however, it is not intended as a policy position for murrelet management, but is meant to show a summary of the assumptions related to these deferrals. Under the 1997 HCP, DNR committed to the development of a long-term conservation strategy for marbled murrelet habitat as part of a five-step process (DNR 1997, pp IV.39-45). In the interim, until inventory surveys are completed, the DNR defers timber harvest activities in all unsurveyed reclassified marbled murrelet habitat on western Washington forested state trust lands.

Schedules for deferral and release of marbled murrelet habitat were used to make assumptions for the range of Alternatives; however, it is presumed that all habitat provisions will remain until a long-term strategy is in place. Marbled murrelet habitat management would be determined through a long-term conservation strategy developed by DNR's scientific staff working in collaboration with the Federal Services, Washington Department of Fish and Wildlife, and other scientific specialists. Once the long-term strategy is developed, its implementation and possible effects on the sustainable harvest level will be examined.

All Alternatives are consistent with implementation of the HCP conservation strategy for marbled murrelets. The variables are the amount of structurally complex forest (the habitat most likely to provide suitable nesting habitat) on western Washington forested state trust lands and timing of when such habitat would appear on the landscape. Section 4.4.4.1 provides a qualitative assessment of the potential for the Alternatives to affect the quantity and distribution of structurally complex forest on forested trust lands. In the short term, Alternatives 1 and 4 are expected to maintain slightly greater amounts of structurally complex forest on forested trust lands than the other Alternatives, and Alternative 5 the least. However, the differences between Alternatives are initially small because it takes time and or active stand management for structurally complex forest to develop. In the long term, structurally complex forest is expected to increase over current levels for all Alternatives except Alternative 5, which is projected to show a small decline. The Preferred Alternative is projected to have the largest percentage of structurally complex forest, 29 percent of the land base, followed by Alternatives 1 and 4 with 27, Alternative 2 with 26, Alternative 3 with 25, and Alternative 5 with 23 (Figure 4.2-4 and Appendix D, Table D-12). Of particular note, more than one-third of structurally complex forests under the Preferred Alternative, or 10 percent of the landbase, is expected to develop into either niche diversification or fully functional forest by 2067. That is a large improvement over current conditions and represents more than twice the improvement in the forest development in those stages as seen in any of the other Alternatives.

The amount of structurally complex forest habitat within 40 miles of marine waters is of particular concern, because the great majority of known marbled murrelet nest sites occur within this distance band (U.S. Fish and Wildlife Service 1997). Appendix D, Table D-16, presents the results of this analysis. In keeping with general trends among the Alternatives across the land base, structurally complex forests increase by 2067 for the Alternatives, except Alternatives 3 and 5. The Preferred Alternative shows the greatest gains in structurally complex forest, with Alternatives 4, 1, and 2 showing slightly lesser gains, in that order (Appendix D, Table D-14).

Other Threatened, Endangered, and Sensitive Species

Other than the northern spotted owl and legacy and reserve tree procedures, none of the Alternatives proposes changes in the policies or procedures that directly address threatened, endangered, and sensitive species. Therefore, differences among the Alternatives would arise from differences in the amount or quality of the habitats with which these species are associated. The availability of such habitats is not expected to change in response to timber harvest activities, but habitat quality can be affected by the harvest of adjacent stands. Harvest activities in adjoining forest stands may affect species viability by flushing adults from nests or dens and leaving the young exposed to an increased risk of predation or starvation.

Analysis of effects to most other species of management concern focuses on the differences in the amount of timber harvest modeled under each Alternative, and the potential effects to the habitats with which they are associated, within the Habitat Conservation Plan (HCP) Planning Units where the species may occur. Greater detail about effects to species associated with structurally complex forest, riparian, wetland, and uncommon habitats can be found in Section 4.4.4.1. Table 4.4-5 lists the criteria by which effects of the Alternatives were evaluated for each species (evaluation criteria are based on the habitat associations and distribution information in Appendix D, Table D-11), and ranks the Alternatives with respect to these criteria. Alternatives with the least potential to result in adverse effects are listed first, followed by those with increasing potential for adverse effects.

Two species, Pacific fisher and Canada lynx, receive additional discussion below. In the case of the lynx, only a few watersheds in the North Puget HCP Planning Unit contain suitable habitat.

Pacific fishers are associated with structurally complex forest, particularly at low elevations. Timber harvest that reduces canopy cover and the availability of large snags and coarse woody debris may decrease the potential for a landscape to support this species

Table 4.4-5. Criteria for Evaluation of the Effects to Threatened, Endangered, and Sensitive Species Other Than Northern Spotted Owl and Marbled Murrelet

Species	Evaluation Criteria [1/] (HCP Planning Units Where Effects May Occur)	Relative Ranking by Alternative[2/]
Mardon Skipper	Effects to uncommon habitats (South Puget and South Coast)	1 4 3 2 PA 5
Oregon Silverspot Butterfly	Effects to uncommon habitats (South Coast)	1 4 2 3 PA 5
Larch Mountain Salamander	(a) Effects to uncommon habitats (b) Amount of structurally complex forest in 2013 (North Puget, South Puget, and Columbia)	(a) 1 4 2 3 PA 5 (b) 1 4 2 3 PA 5
Oregon Spotted Frog	Effects to wetlands (South Puget and Columbia)	1 4 2 3 5 PA
Western Pond Turtle	Effects to wetlands (North Puget, South Puget, Columbia, and South Coast)	1 4 2 3 5 PA
Common Loon	Amount of timber harvest (all HCP Planning Units except Columbia)	1 4 2 3 PA 5
Aleutian Canada Goose	Effects to wetlands (North Puget, South Puget, Columbia, and South Coast)	1 PA 4 2 3 5
Bald Eagle	Amount of structurally complex forest, (a) short-term and (b) long-term (all HCP Planning Units)	(a) 4 1 2 3 PA 5 (b) PA 4 1 2 3 5
Peregrine Falcon	(a) Amount of timber harvest activity; (b) effects to wetlands (all HCP Planning Units)	(a) 1 4 2 3 5 PA (b) 1 PA 4 2 3 5
Sandhill Crane	Effects to wetlands (Columbia)	1 4 2 3 5 PA
Western Gray Squirrel	Amount of timber harvest (South Puget and Columbia)	PA 1 2 3 4 5
Gray Wolf	Amount of timber harvest (North Puget, South Puget, and Columbia)	1 PA 2 4 3 5
Grizzly Bear	Amount of timber harvest (North Puget and South Puget)	1 4 3 2 5 PA
Pacific Fisher	Amount of structurally complex forest in low-elevation watersheds [3/5/]	PA 3 1 2 4 5
Canada Lynx	Harvest activity in high-elevation watersheds[4/5/] (North Puget, South Puget, and Columbia)	PA 5 2 3 4 1
Columbian White-Tailed Deer	Effects to riparian areas (Columbia)	1 4 2 3 5 PA

Notes:

[1/] See Appendix D, Table D-11 for the habitat association and distribution information that serves as the basis for these evaluation criteria.

[2/] Alternatives with the least potential to result in adverse effects are listed first, followed by those with increasing potential for adverse effects.

[3/] Defined as watersheds where >50% of forested trust lands are in the western hemlock or sitka spruce vegetation zones.

[4/] Defined as watersheds where >1% of forested trust lands are in the alpine or parkland vegetation zone, and >30% are in any combination of the parkland, mountain hemlock, and Pacific silver fir zones.

[5/] The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations.

PA= Preferred Alternative

Data Source: Model output data – stand development stages.

(Lewis and Stinson 1998). In western Washington, most low-elevation forest falls in the western hemlock or Sitka spruce potential vegetation zones, which are also the most productive zones for timber (see Section 4.2 for a discussion of vegetation zones). None of the Alternatives contains any specific provisions for the protection of low-elevation forest, and most would be expected to emphasize timber production from these areas; however, extensive acreage is dedicated to conservation benefits or other resource protection

objectives that provide direct and indirect benefits to a number of species. The amount of forest management activities may potentially be offset by the relatively faster development of structurally complex forest in these more productive areas. The rate and amount would vary by Alternatives. Model results support this assumption, predicting greater increases in the availability of structurally complex forest in low-elevation areas compared to overall (Appendix D, Table D-15).

An analysis of the net change in the availability of structurally complex forest in watersheds that are dominated by low-elevation vegetation shows a pattern similar to that modeled for structurally complex forest overall (Appendix D, Table D-14 and D-15; compare to Appendix D, Table D-12). In both analyses, increases from current conditions result in all time periods under all Alternatives, with the greatest short- term increases anticipated under Alternatives 1 and 4, and greatest long-term increase occurring under the Preferred Alternative.

No significant impacts beyond the effects anticipated in the HCP Environmental Impact Statement (EIS) or the Forest Practices EIS are expected to low-elevation structurally complex forests, or by association, Pacific fisher and its habitat. Canada lynx are associated with high-elevation areas in the state of Washington. Most western Washington forested state trust lands are in lower elevation areas; only 10 watersheds (all in the North Puget HCP Planning Unit) meet the criterion of at least 1 percent of forested trust lands in the alpine or parkland zone. Additionally, these watersheds contain some area in mountain hemlock and/or Pacific silver fir zones. Dense, young forest with abundant understory is primary habitat for the Canada lynx's main prey—the snowshoe hare—and thus provides foraging habitat for the lynx; therefore, timber harvest, especially thinnings within competitive exclusion stands, in watersheds in high-elevation areas would likely create greater numbers of young forest stands and may improve foraging opportunities in some areas where forage is lacking for the Canada lynx. Snowshoe hare prefer the dense cover of coniferous and mixed forests; abundant understory cover is important. Coniferous swamps and second-growth areas that are adjacent to mature forests, and alder fens and conifer bogs, are also utilized.

Any benefits of providing additional forage habitat may be offset by disturbance to these animals during harvest activities (of particular concern if lynx are breeding in the vicinity), and possible reductions in the availability of down woody debris, which provides cover and denning sites. Model results (Appendix D, Table D-17) indicate that the greatest amount of timber harvest in high-elevation watersheds is anticipated under Alternative 5, followed in descending order by Alternatives 3, 2, 4, Preferred Alternative, and Alternative 1. The proportion of forested trust land harvested in these watersheds per decade ranges from 3.6 percent (Alternative 1) to 5.6 percent (Alternative 5), well below the proportions modeled for all forested trust lands (see Table 4.9-1). No significant adverse impacts are therefore anticipated to Canada lynx under Alternatives 2 through 5 and the Preferred Alternative relative to Alternative 1 (No Action).

Deer and Elk

Effects of the Alternatives on deer and elk can be evaluated by comparing the number of watersheds in which the amount of deer and elk foraging habitat on forested trust lands is between 30 and 60 percent of the total forested trust lands. This proportion of foraging habitat ensures ample foraging opportunities for these species, without compromising the availability of densely forested areas that provide cover. For this analysis, ecosystem initiation forest and structurally complex forest are considered to provide foraging habitat. Currently, the majority of forested trust lands are in competitive exclusion forest that does not provide foraging habitat. Thus, Alternatives that result in the greatest amount of open or structurally complex forest—or both—would be expected to provide the greatest improvements in habitat conditions for these species. Estimated proportions of western Washington forested state trust lands comprised of structurally complex forest increase over time under all Alternatives (Appendix D, Table D-12). The Preferred Alternative is anticipated to result in 29 percent of the landscape converting to structurally complex forest by 2067.

In the short term, most Alternatives would reduce the number of watersheds in which foraging habitat is between 30 and 60 percent. However, through 2067, all Alternatives show an increase in the number of watersheds providing suitable foraging habitat (Table 4.4-6). Alternative 4, followed by the Preferred Alternative would result in the greatest improvements.

Alternative 4, which employs a more passive management approach to resource protection, results in the smallest increase in 2013, likely associated with the decrease in the amount of ecosystem initiation forest. Alternatives 2, 3, and 5 result in smaller increases that are through 2013, while the largest short-term increase is modeled as occurring under the Preferred Alternative.

By 2067, the nominal duration of the Habitat Conservation Plan, Alternative 4 would result in the greatest increase in the number of watersheds with 30 to 60 percent foraging habitat, followed in descending order by the Preferred Alternative, and Alternatives, 3, 2, 1, and 5 (Table 4.4-6). Despite differences in the amount of deer and elk foraging habitat created, significant environmental impacts beyond existing conditions are not anticipated in any of the six Alternatives. With the exception of Alternative 5, all projected gains in foraging habitat for deer and elk for all other Alternatives are comparable or greater than those projected for Alternative 1 (No Action).

Table 4.4-6. Change Over Time Relative to the Current (2004) Number of Watersheds[1/] in which 30 to 60 Percent of Forested Trust Lands Would Provide Deer and Elk Foraging Habitat, under Each Alternative

Alternative	Change In Number of Watersheds With 30% to 60% Forage		
	Year 2013	**Year 2031**	**Year 2067**
1	-13	-21	20
2	-9	-1	19
3	1	1	22
4	-22	-2	29
5	-14	1	10
Preferred Alternative	7	7	23

Data Source: Model output data – stand development stages.

[1/] The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations, and percent totals are based on the total acres of forested trust lands per WAU.

4.5 AIR QUALITY

4.5.1 Summary of Effects

This section analyzes the environmental effects on air quality. The analysis examines the effects of prospective changes to current policy and procedures, and uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

None of the proposed Alternatives would create new policies or procedures related to air quality. Impacts related to air quality would result from the projected forest management activities associated with each of the Alternatives.

The Alternatives differ slightly in their effects to air quality, but none of the Alternatives has the potential for significant environmental impacts relative to current conditions, beyond those anticipated in the Habitat Conservation Plan (HCP) Environmental Impact Statement (EIS). Air pollution from dust would be mitigated by dust abatement measures under all Alternatives, and the total amount of prescribed burning would likely continue to be below the level anticipated in the HCP.

4.5.2 Affected Environment

Air quality is regulated by the federal Clean Air Act, which requires the U.S. Environmental Protection Agency to set national ambient air quality standards for pollutants considered harmful to public health and the environment. “Ambient air” refers to that portion of the atmosphere, external to buildings, to which the general public has access. An air quality standard establishes values for maximum acceptable concentration, exposure time, and frequency of occurrence of one or more air contaminants in the ambient air. Ambient air quality standards have been set for six principal pollutants: carbon monoxide, nitrogen dioxide, ozone, lead, particulate matter, and sulfur dioxide.

Prescribed burning on forestland is regulated by DNR’s Resource Protection Division, which requires a permit for burning. DNR’s smoke management plan provides regulatory direction, operating procedures, and information regarding the management of smoke and fuels on the forestlands of Washington. The plan coordinates and facilitates the statewide regulation of prescribed burning on forested trust lands, as well as on federally managed forestlands and participating tribal lands. The plan is designed to meet the requirements of the Washington State Clean Air Act.

Other activities on DNR-managed forested trust lands that may affect air quality are regulated by regional agencies responsible for enforcing air quality laws in Washington. These agencies regulate a wide range of air pollution sources. They also monitor air quality.

The main sources of air pollution in western Washington include motor vehicles (55 percent), industrial (13 percent), and wood stoves (9 percent). Approximately 4 percent is generated from outdoor burning, a portion of which comes from forest management activities (Washington State Department of Ecology 2003). Air quality in western

Washington is generally good or moderate, although some areas do not meet federal standards on some days. Air quality has improved greatly since 1987, when Washington violated air quality standards on 150 days. This figure dropped to 7 in 1999 (Washington State Department of Ecology 2003).

4.5.2.1 Silvicultural Burning

Broadcast burning is the practice of burning logging slash scattered throughout a recently harvested unit to prepare the site for planting and/or to reduce dangerous fuel loads. Between 1997 and 2002, approximately 15 acres of DNR-managed forested trust lands were broadcast-burned each year to reduce slash, considerably less than the 500 to 1,000 acres anticipated in the Habitat Conservation Plan (HCP) Environmental Impact Statement (EIS) (DNR 1996).

During this same period, approximately 269 acres per year of pile burning took place. This is the practice of reducing logging slash by collecting the slash in piles and burning the piles. By burning under wetter conditions, usually in the spring, fewer particulates are emitted than would be the case if the same fuels burned in a wildfire. Particulate emissions from wildfires are, on average, three to four times higher than from prescribed burning (DNR 1996). Wildfire risk is discussed in Section 4.2 (Forest Structure and Vegetation).

4.5.2.2 Air-Borne Dust

The use of logging roads during dry periods generates air-borne dust. Air-borne dust is regulated through road maintenance standards of the Washington Forest Practices Board (Washington Administrative Code 222-24) and safety standards of the Washington Department of Labor and Industries (Washington Administrative Code 296-54). The amount of air-borne dust is a function of road use and surfacing material. Gravel can reduce dust (Washington State Department of Ecology 2001), as can water and chemical dust (DNR 1996) suppressants. In general, the adverse effects of air-borne dust are localized and short term (DNR 1996).

4.5.2.3 Forestland and Air Quality

One of the ecological benefits of forested trust lands is the enhancement of air quality. Plants enhance air quality by emitting oxygen and consuming carbon dioxide, the gas most associated with global warming. (see Section 4.2 for a discussion of the carbon cycle and carbon sequestration.) In addition, trees retard the spread of air-borne particulates by trapping the material on their leaf surfaces and by slowing the wind speed to the point that particulates cannot remain suspended. Timber-harvesting temporarily removes the air quality benefits provided by trees (DNR 1996).

4.5.3 Environmental Effects

Impacts related to air quality would be minor under all Alternatives. Traffic on dirt roads would add dust to the air, and prescribed burning and wildfires would add smoke. The dust and smoke could produce eye and respiratory discomfort to people working, living, or recreating in the area. Smoke, especially from wildfires, could adversely affect air quality over a wide area, which could include urban areas.

Alternative 3 is projected to harvest more timber than the other Alternatives, followed by Alternatives 5, 2, the Preferred Alternative, and Alternatives 1 and 4, in that order. Alternative 3 is projected to harvest more in some decades than Alternatives 2, 5, and the Preferred Alternative and less in other decades, but the overall level is higher (refer to Figure 4.2-1). Alternatives 1 and 4 would harvest the least amount of timber in all decades. Harvest activity is likely to result in more traffic by log trucks and vehicles driven by other forest workers. Alternative 3 would, therefore, have a greater potential to generate dust than the other Alternatives. Alternatives 1 and 4 are projected to have the lowest harvest levels over the planning period, and would, therefore, have a lower potential to generate dust. Alternatives 2 and 5 and the Preferred Alternative are intermediate. Air pollution from dust would be mitigated by dust abatement measures under all Alternatives.

The use of prescribed burning to prepare a site for planting is projected to be similar to current levels under all of the Alternatives. It is likely to be slightly lower under Alternatives 1, 4, and the Preferred Alternative and slightly higher under Alternatives 2, 3, and 5. Any burning would be regulated by the Washington State Smoke Management Plan. Few or no additional adverse effects on air quality are anticipated to result from prescribed burning for site preparation under any of the proposed Alternatives. Policy No. 10 of the Forest Resource Plan directs DNR to take preventive measures to reduce extreme fire hazards on forested trust lands. This is not anticipated to result in many acres of prescribed burning on the westside due to cool and wet weather patterns that generally prevail. The sum of all prescribed burning is likely to continue to be far below the level anticipated in the Habitat Conservation Plan regardless of which Alternative is selected.

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Chapter 4

4.6 GEOMORPHOLOGY, SOILS, AND SEDIMENT

4.6.1 Summary of Effects

This section analyzes the environmental effects on geomorphology, soils, and sediment. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

Significant increases in landslide frequency or severity and loss of soil productivity relative to current conditions, beyond those anticipated in the Habitat Conservation Plan (HCP) Environmental Impact Statement (EIS), are not anticipated under any of the Alternatives. Increased soil erosion may occur in certain intensely managed areas as road use increases. Further discussion of relative impacts among the HCP Planning Units and for individual watersheds is included in Cumulative Effects (Section 4.15). The Alternatives are ranked according to percent of uplands impacted per decade by intensity of harvest type (Table 4.6-8). By this ranking, Alternative 5 carries the highest potential overall relative impact, followed by Alternatives 2, 3, the Preferred Alternative, 4, and 1.

The public comments requested that the Final EIS review the differences between Alternatives with regard to forest roads. Section 4.6 presents information relevant to road impacts. In general, it is not expected that the number of road miles or road density will vary as a result of the implementation of any of the proposed Alternatives. While the Final EIS Alternatives propose different harvest timings and locations, the basic road network statewide will evolve to the end condition, over time, virtually independent of which Alternative is chosen. Road-spacing is mostly dependent on topography. Topography drives the type of logging system used to achieve the desired silvicultural objectives, which in turn dictates optimal yarding distance to road-spacing combinations. This is illustrated by Table 4.6-3, Road Density by Deferral Class under the Preferred Alternative in 2004. The table shows that there are small differences between road density in areas that would be deferred from harvest under the Preferred Alternative and the areas that would allow activity.

Road impacts for all the Alternatives should be well within the range anticipated by the HCP due to the relationship to the total acres harvested. As indicated in Table 4.6-4, harvest levels in each of activity types for each of the Alternatives are within those expected under the HCP and analyzed in the HCP Draft and Final EIS. The HCP Draft EIS (DNR 1996) analyzes effects related to sediment (p. 4-163) and stream flow (p. 4-170). Mitigation in the form of Riparian Management Zones, management for hydrologically mature forest in the significant rain-on-snow zones, wetland protection, and road management planning (identified above) are detailed in those sections.

The Washington Forest Practices Rules Final EIS (DNR 2001) also presents an analysis of the effects of sediment, peak flows, roads in riparian areas and wetlands on water quality and on fish. A discussion of sediment is contained in Section 3.2 (p. 3-7), which discusses road surface erosion and road-related landslides. The evaluation of the Alternatives in this analysis offers the 2001 rules package that provides measures necessary to address impacts due to road-related sedimentation (p. 3-16). These mitigation measures include implementation of road maintenance and abandonment plans and the adaptive management program. In addition, Appendix F in the Final EIS for the Forest Practices Rules discusses the effects of road construction and maintenance and describes recommended and accepted practices for building and maintaining roads. It states that, “Roads built following Forest Practices Rules that provide specific direction and recommended Best Management Practices (BMPs) from the literature have the lowest risk of causing sediment delivery” (p. F-2). As stated above, all of the Alternatives will meet the requirements as specified in the Forest Practices Rules.

4.6.2 Introduction

Geomorphology, soils, and sediment in western Washington are products of interactions among the geology, climate, and ecosystems. Timber harvest can have environmental effects on these systems. Issues related to geomorphology, soils, and sediment identified during scoping include sediment movement and soil productivity. Evaluation of sediment movement and deposition is important to understand the potential ecological impacts. Sediment, if delivered to streams can result in adverse effects to fish and aquatic habitat, and loss of soil productivity in both upland and riparian areas. Sediment movement can be increased beyond background levels as a result of forest management activities, including timber harvest and road-building and use.

As discussed in Forest Practices Rules Final Environmental Impact Statement (EIS), Section 3 (Washington Forest Practices Board 2001), mass wasting, or the gravity-induced down-slope movement of loose soil and rock, may deliver large volumes of sediment to streams. This may result in pool filling and loss of rearing habitat for fish. Surface erosion also delivers sediment to streams, which may result in degradation of spawning habitat.

Soil is an important resource because it provides the medium for the growth of trees and other vegetation, and is a key factor in the productivity of forests.

Effects on mass wasting, surface erosion, and soil productivity are examined in this section through the comparison of current conditions and environmental sensitivities to relative projected harvest levels among the six Alternatives.

4.6.3 Affected Environment

The following descriptions of the affected environment with respect to mass wasting, surface erosion, and soil productivity were synthesized largely from information presented in the 1997 Habitat Conservation Plan (HCP) (DNR 1997) and the 2001 Forest Practices Rules Environmental Impact Statement (EIS) (Washington Forest Practices Board 2001). These were supplemented with peer-reviewed references and data generated from the Alternatives modeling analysis. DNR evaluates slope stability and other geomorphologic interactions during site-specific timber sale design. A significant part of the evaluation is the use of the expanded Environmental Checklist (see Section 4.15, Cumulative Effects), which adds approximately 100 additional questions to the original checklist. These questions focus on environmental issues associated with forest management. An understanding of interactions among geology, climate, and ecosystems can lead to balanced actions that minimize significant adverse environmental impacts. Characterizing landforms and ecosystem processes, both biotic and abiotic, increases conservation benefits while meeting fiduciary responsibilities.

A number of processes are important in understanding the potential for significant adverse environmental impacts. These include mass wasting, surface erosion, and changes in soil productivity, which are discussed below.

4.6.3.1 Mass Wasting

Management activities that potentially increase the risk of mass wasting include road building and timber harvest (Washington Forest Practices Board 2001). Careful harvest and road planning can reduce the risk of mass wasting due to management activities and its effects. Sediment produced as a result of forest management activities can be delivered to the aquatic system from episodic landslides initiated and adjacent to harvested areas.

Mass wasting events provide episodic sources of fine and coarse sediment and organic debris to the aquatic systems in western Washington. Various types of landslide detachments and processes can be considered mass wasting. Some are deep-seated, in which most of the area of the slide plane or zone lies beneath the maximum rooting depth of forest trees, sometimes to depths of tens or hundreds of feet. Others are shallow-rapid, in which the landslide plane or zone is within the maximum rooting depth of forest trees. Further distinctions can be made based on the failure mechanism and composition of the resulting mass wasting event or landslide.

Landslides are the result of failure of the cohesive and frictional strength of the slope material (e.g., vegetation, soil, subsurface deposits). This loss of material strength can be caused by a variety of factors, including loss of root strength, increased pore-water pressure, or inherently low shear strength of subsurface materials. Slope length, shape, and aspect are also natural variables that influence landslide risk for a given slope. Mass wasting events generally correlate with high precipitation events, changes in drainage, removal of vegetation, removal of material downslope of the failure, or loading of material into an unstable slope. Additionally, streambanks may be susceptible to bank undercutting or failure if streamside vegetation is removed (in the event that no stream buffer exists). See the Forest Practices Rules Final Environmental Impact Statement (EIS), page 3-10 (Washington Forest Practices Board 2001) for further discussion.

Root strength studies (e.g., Wu et al. 1979; Wu and Swanston 1980; Ziemer 1981) have led to a semi-quantitative understanding of the impact of decreasing root strength on slope stability. A relatively recent study (Dhakal and Sidle 2003) indicates that thinning and retaining vigorous understory vegetation should reduce landslide volumes and frequencies over regeneration harvest activities.

The role of mass wasting in aquatic systems is described in more detail in the Forest Practices Rules Final EIS (pages 3-7 through 3-25, Washington Forest Practices Board 2001). Potential impacts from road-building and timber harvest are minimized through effective planning, design, and review of appropriate harvest practices on all non-federal lands in Washington with special requirements on unstable or potentially unstable slopes.

Removal of timber can cause increases in the availability of atmospheric water to contribute to increases in groundwater and surface runoff (primarily as peak flows), as discussed in Section 4.7 (Hydrology). The evapotranspiration and interception properties of the forest change through the removal of some or all of the forest canopy. Increases in groundwater levels, and duration of seasonal high groundwater conditions, can contribute to higher porewater pressures, and thereby potentially destabilize slopes. Increased storm and seasonal runoff can result in increased peak flows, stream incision, and undercutting of potentially unstable slopes (CMER 2004). Because of these potential effects, the effects of timber harvest and road-building on groundwater recharge and stream flow will be analyzed for each planning area where slope stability may be affected by these increases.

4.6.3.2 Surface Erosion

Generally, forest vegetation stabilizes soils, reduces soil erosion, and slows sediment transport to streams, thereby minimizing the impact of sedimentation on water quality. However, surface erosion from roads, harvest units, and skid trails tends to be a chronic source of fine sediment to the drainage network, as well as an episodic source of coarse sediment. Chronic sources of fine sediment can have potentially significant adverse effects on the physical habitat of the aquatic system and certain lifestages of aquatic biota, degrade water quality, and affect soil productivity in both riparian and upland areas.

Road-related surface erosion and delivery of fine sediments to streams is a concern because of the thousands of miles of forest roads that exist to transport harvested timber in forested regions of western Washington. Surface erosion is affected by slope gradient and shape, soil texture properties (density, cohesion, sorting, etc.), parent material, precipitation, groundwater movement, vegetation cover, and human activities. Rates of sediment delivery to streams, predominantly from timber haul (heavy truck traffic) but also public use of unpaved roads, is correlated to traffic volume, design and maintenance of the road and associated drainage structures, and the location of the road relative to streams (USDA Forest Service 2001; Rashin et al. 1999; Reid and Dunne 1984). The amount and types of traffic and road maintenance practices also influence delivery. For a detailed discussion of transportation infrastructure on forested trust lands, see Chapter 4, Section 4.11.3, Public Utilities and Services.

Harvest activities such as ground-based skidding or cable yarding can cause soil disturbance. Streamside vegetation and hillslope roughness can trap sediment, controlling the amount that reaches the stream system. These filtering capabilities are affected by timber harvest within and adjacent to streamside buffers. However, additional harvest materials left on the forest floor can help offset decreases in filtering capability adjacent to the streamside buffer. See the Forest Practices Rules Final EIS (page 3-9, Washington Forest Practices Board 2001) and the Habitat Conservation Plan Final EIS (DNR 1996, Sections 4.2.3, 4.4.2, and 4.6).

4.6.3.3 Soil Productivity

Soil productivity is a soil's capacity to support vegetation. Long-term productivity is a soil's capacity to sustain the natural growth potential of plants over time (Section 4.6 of the Habitat Conservation Plan [HCP] Final Environmental Impact Statement [EIS]). Forest management relies on soil productivity to help provide conservation benefits and to support a productive forest ecosystem that provides financial support to the beneficiaries.

Soil productivity is a function of a variety of parameters, both within the soil and external to it. Internal parameters include bulk density or porosity; amount of organic matter; and levels of carbon, nitrogen, and other beneficial minerals; as well as the presence of organisms within the soil (e.g., earthworms, mycorrhizal fungi) that aerate the soil or allow the uptake of nutrients from the soil by plants. External conditions, such as microclimate, slope aspect, and precipitation will also influence internal conditions of soil temperature and soil moisture.

Timber harvest and road-building can affect soil productivity. Factors involved include harvest location relative to sensitive soils and soil moisture; type, area, and frequency of disturbance related to harvest; the amount of large wood left on site; reforestation methods; and fertilization. Disturbance from felling, yarding, and skid trails can cause soil compaction, which can affect soil productivity (page 3-9, Washington Forest Practices Board 2001). Burning and mechanical clearing have the potential to reduce soil productivity for sensitive soils.

Productivity can be degraded or improved by forest management in a variety of ways (USDA Forest Service 2002b; Heninger et al. 2002; Miller et al. 1992). Removal of trees and site preparation can increase soil temperature and erosion; yarding and felling can compact soils or remove organic layers if trees are pushed or dragged along the ground surface; and burning can change the mineralogy of soil, decrease nutrient content, and create hydrophobic conditions. Adverse impacts may be amended or masked by fertilization. Fertilization and control of undesirable vegetation may improve the productivity of desirable species. Gessel et al. (1990) summarized four decades of fertilization studies in Pacific Northwest Douglas-fir forests, demonstrating the response of Douglas-fir to fertilization, especially nitrogen fertilization, in western Washington and Oregon.

Soil development in most forestlands of western Washington has been occurring for at least the last 10,000 years following glacial retreat, occasionally disrupted by landslide events, mudflows, volcanic eruptions, or flooding (Franklin and Dyrness 1988). However, accelerated rates of mass wasting have the potential to impact local soil productivity. Soil disturbance as a result of mass failure generally transports productive soil layers in which most of the organic material, available nutrients, and beneficial mycorrhizal associations reside. Disruption and removal of productive soil layers can occur as they are transported downslope and are mixed with other material. Depending on the species desired and type of landslides initiated, increased frequency of mass wasting may affect soil productivity by removal, disruption, and transport of near-surface soil layers. Red alder is a nitrogen-fixing species that can establish itself in soils with minimal development, while establishment of productive stands of conifers generally requires several decades for natural succession on young soils (Franklin and Dyrness 1988). If bedrock is exposed, a local loss of productivity would occur in the area of bedrock exposure that would require a significantly longer time for the development of productive soil with adequate rooting depth than in the runout and deposition zones.

STAND MANAGEMENT METHODS

The methods used to manage forest stands can affect soil health and productivity. Ground-based systems and cable systems without full suspension have the greatest potential to increase compaction or surface erosion, which can decrease soil productivity for some soils.

Forest fertilization can improve harvest yields and may improve forest health for some sites. Fertilization includes both aerial and ground applications. Other practices such as site preparation and vegetation management are important management tools to either protect or increase harvest yields. Site preparation includes a variety of techniques, such as aerial and ground herbicide applications, broadcast burns, ground mechanical treatments, and pile and burn. Vegetation management includes aerial and ground herbicide applications, and mechanical and hand vegetative control methods. Forest Resource Plan policies regarding Silviculture, Policies 30 through 34, guide the application of these practices.

4.6.3.4 Existing Conditions on Western Washington Forested State Trust Lands

Mass Wasting

Deep-seated landslides have been identified on less than 3 percent of forested trust lands in western Washington (Table 4.6-1). Areas identified through slope stability modeling as having a high potential for shallow-rapid landslides represent between 6 and 21 percent, by HCP Planning Unit, and overall approximately 12 percent of forested trust lands in western Washington (Table 4.6-2). If correctly identified, these areas are more susceptible to mass wasting under certain types of forest management and require additional investigation before forest management may be planned to occur on them compared to most harvest areas. The North Puget HCP Planning Unit has the greatest overall amount of area identified or classified as potentially unstable, while the Olympic Experimental State Forest contains the greatest percentage as a proportion of all lands in that HCP Planning Unit. See Appendix E, Tables E-29 and E-30, for a ranking of watersheds with greater than 5 percent DNR ownership by the percentage of land classified as “high” and “moderate” (respectively) for potential shallow-rapid slope instability (based on the SMORPH model).

Table 4.6-1. Areas of Mapped Landslides and Potentially Unstable Slopes on Forested Trust Lands, by HCP Planning Unit

HCP Planning Unit	Total Acres in HCP Planning Unit	Acres of Identified Landslides[1/]	Acres of Landslides that Have Occurred[2/]	Acres Modeled as High for Potential Slope Instability[3/]
Columbia	267,530	8,282	171	16,525
North Puget	381,516	13,476	2,146	52,388
OESF	256,659	2,886	1,646	53,296
South Coast	232,931	5,478	261	23,254
South Puget	141,846	890	3,252	11,560
Straits	110,222	1,851	3	14,157
Westside Total	**1,390,704**	**32,864**	**7,479**	**171,181**

Data Sources:
[1/] DNR Geoslide Geographic Information System Data; only deep-seated landslides.
[2/] DNR Landslide Geographic Information System Data; both deep-seated and shallow-rapid landslides.
[3/] DNR SMORPH Geographic Information System Data (10-meter slope stability model); predicted (modeled) shallow-rapid landslides.
OESF = Olympic Experimental State Forest

Table 4.6-2. Areas of Mapped Landslides and Potentially Unstable Slopes on Forested Trust Lands as a Proportion of Total Forested Trust Lands in Western Washington, by HCP Planning Unit

HCP Planning Unit	Area of Mapped Landslides[1/]	Area Modeled as High for Potential Slope Instability[2/]
Columbia	3.2%	6.2%
North Puget	4.1%	13.7%
OESF	1.8%	20.8%
South Coast	2.5%	10.0%
South Puget	2.9%	8.1%
Straits	1.7%	12.8%
Westside Total	**2.9%**	**12.3%**

Data Sources:
[1/] DNR Geoslide and Landslide Geographic Information System Data, including both deep-seated and shallow-rapid landslides.
[2/] DNR SMORPH Geographic Information System Data (10-meter slope stability model); predicted (modeled) shallow-rapid landslides.
OESF = Olympic Experimental State Forest

Surface Erosion

ROADS AND THE ALTERNATIVES

Forest roads are an integral part of forest management (Habitat Conservation Plan, page IV.62-68). DNR has an important and considerable task of repairing and maintaining approximately 14,000 miles of forest roads statewide. It is expected that roads will be added and deleted to meet financial, social, and environmental objectives.

It is not expected that the number of road miles or road density will vary as a result of the implementation of any of the proposed Alternatives. Below is a discussion of DNR's obligations for roads management, and an analysis of DNR's road network, both present and future. An analysis of differences among the Alternatives with respect to levels of surface erosion and truck traffic resulting from harvest levels proposed under different Alternatives can be found in this section, and in Chapter 4, Section 4.11, respectively.

The Alternatives and the Habitat Conservation Plan

The basic structure of Habitat Conservation Plan (HCP) commitments for forest roads is stated in the *Riparian Conservation Strategy for the Five Westside Planning Units*, Part IV, Section D. DNR committed to the following principles for road network management:

1. Minimization of active road density;
2. Site-specific assessments of alternative harvesting systems that require less road construction;
3. A base line inventory of roads and stream crossings;
4. A prioritized system for road decommissioning, upgrading, and maintenance; and
5. Identification of fish blockages caused by stream crossing structures, and a prioritized approach to repair or removal.

In addition, RCW 76.09, the Forest Practices Act, regulates DNR. This Act contains many sections designed to provide regulations for protection of the environment. The Forest and Fish regulations were passed into law after DNR's Habitat Conservation Plan agreement, and have significantly raised the level of environmental protection with respect to road management, unstable slopes, and fish blockage repair. Additionally, each road that is constructed is further evaluated under the State Environmental Policy Act as a part of DNR's review of timber sale projects occurring on state lands.

There have been a number of accomplishments related to roads management since the HCP was implemented, including:

1. Baseline inventory of roads completed in December 1999;
2. Inventory of all stream crossings and assessment and prioritization of culvert blockages completed in April 2001;
3. 223 fish blockages repaired or abandoned;
4. 907 miles of road decommissioned or abandoned;
5. HCP guidelines for assessment of potentially unstable slopes completed in September 2003; and

6. As of December 31, 2003, approximately 75 percent of HCP Planning Unit roads completed under approved Road Maintenance and Abandonment Plans according to Forest and Fish regulations. The law requires DNR to be 60 percent complete.

Harvest Timings

While the Final Environmental Impact Statement (EIS) Alternatives propose different harvest timings and locations, the basic road network statewide will evolve to the end condition, over time, virtually independent of which Alternative is chosen. As stated in DNR's HCP, "In considering road densities, it is assumed that the current emphasis on small staggered settings with green-up requirements, and partial-cut silvicultural systems designed to achieve environmental objectives will continue. These systems will, by their nature, result in more extensive road systems, which will be active for longer periods of time. While expansion is inevitable, as new areas are accessed, DNR's goal will be to reduce the additional amount of new roads needed through careful planning, and control the overall size of the network by effective abandonment" (Part IV section D, page 66).

DNR carefully weighs the impacts of roads with regards to environmental protection, public use, and forestland management needs. Where appropriate, roads are abandoned. Also where appropriate, DNR uses alternative harvest systems. A specific road density target was not set in the HCP because such a target would compromise the environmental and economic management of DNR's road networks.

Road-spacing is mostly dependent on topography. Topography drives the type of logging system used to achieve the desired silvicultural objectives, which in turn dictates optimal yarding distance to road-spacing combinations.

Road Density

Below is a road density analysis for western Washington forested trust lands using the distribution of deferral classes that would be implemented for the Preferred Alternative. Acreages in each deferral classification differ by Alternative, but road densities by deferral class are analogous for all Alternatives.

Table 4.6-3 shows the distribution of roads and their density on western Washington forested trust lands, including Natural Area Preserves and Natural Resource Conservation Areas. The data identify density (expressed in average number of road miles per square mile.

The analysis shows that there is a small difference in road density on the average for lands that are currently on-base versus what is in short-term deferral. It also identifies that while there are areas that are in long-term deferral, such lands will often already contain roads necessary to manage nearby forested trust lands.

Table 4.6-3. Road Density Analysis by Deferral Class under the Preferred Alternative in 2004

Deferral Class	Miles	Acres	Density: Road miles/square mile[1/]
Short-term deferral (2004 – 2013)	1,428	302,439	3.02
Long-term deferral (>2013)	703	213,049	0.47
On-base	5,896	875,216	4.31
Total	**8,027**	**1,390,704**	

1/ Calculated by dividing total road miles in each deferral class by the number of square miles in those classes.
Data Source: DNR Forest Practices Transportation Layer.

The HCP estimated a range of annual harvest activity for the six Westside HCP Planning Units (including the Olympic Experimental State Forest). It anticipated a range from almost 23,000 acres to more than 31,000 acres.

Regeneration harvest acreage under the Preferred Alternative are between 71 percent and 90 percent of what was anticipated in the HCP. The number of acres thinned under the Preferred Alternative is between 35 percent and 52 percent of that anticipated under the HCP. The Preferred Alternative regenerates and thins substantially fewer acres than projected by the HCP.

Road impacts for all the Alternatives should be well within the range anticipated by the HCP due to the relationship to the total acres harvested.

Sedimentation

As indicated in Table 4.6-3, much of DNR's current land base is already actively managed and already accessed by roads. DNR's road network is spread across all forested trust lands irrespective of the current "on-" or "off-" base options for harvest scenarios. Further, DNR's road network is managed for multiple use. Timber harvest is only part of the road management equation; recreation, silviculture, and wildfire, etc. play important roles in road strategies and traffic load, all of which are factors in the sediment production and delivery processes.

Although harvest levels are partially related to overall traffic levels on forest roads, truck traffic or road length are unlikely to be the main causes of sedimentation. Sedimentation processes that occur in managed forests are complex and are the result of several factors.

In assessing road surface erosion, sedimentation processes are more of a complex factor than the number of truck miles driven on the roads. Topography, aspect, surface materials, construction/maintenance techniques, proximity to riparian area, micro-climates, time of year, storm events, and public use, etc. play a role in sedimentation. It would be inaccurate to assert that if the number of trucks on a road were reduced, then sediment delivery to fish-bearing water would therefore also be necessarily reduced. Roads that have not yet been updated to be in compliance with the Forest Practices Rules are at greater risk for sediment production than those that have been updated. One of the objectives of the Road Maintenance and Abandonment Plans is to have roads constructed in a manner that prevents the delivery of sediment to stream, regardless of levels of truck traffic.

DNR has performed analyses of its road management and road-related impacts in the context of the existing road network and uses. Analysis of the overarching strategies from the Habitat Conservation Plan (HCP) and the Forest and Fish (Washington Forest Practices) Rules are outlined below.

As indicated in Table 4.6-4, harvest levels in the activity types for each Alternative are within those expected under the HCP and analyzed in the HCP Draft and Final Environmental Impact Statement (EIS). The HCP Draft EIS (DNR 1996) analyzes effects related to sediment (p. 4-163) and stream flow (p. 4-170). Mitigation in the form of Riparian Management Zones, management for hydrologically mature forest in the significant rain-on-snow zones, wetland protection, and road management planning (identified above) are discussed in those sections.

The Washington Forest Practices Rules Final EIS (DNR 2001) also presents an analysis of the effects of sediment, peak flows, and roads in riparian areas and wetlands on water quality and on fish. Sediment is discussed in Section 3.2 of the Forest Practices Rules Final EIS (p. 3-7), which includes road surface erosion and road-related landslides.

Table 4.6-4. Summary of Activity Levels: Acres by Harvest Type

	HCP Expected Annual Activity Levels[1/] (acres)			Alternatives					
Activity[2/]	**Five Westside HCP Planning Units**	**OESF**	**Total**	**1**	**2**	**3**	**4**	**5**	**PA**
Regeneration Harvests[C]	14,000-16,500	300-1,500	14,300-18,000						
Salvage[C]	0	150-250	150-250	8,300	12,700	14,200	7,800	13,400	13,000
Seed Tree[C]	50-100	0-30	50-130						
Shelterwood[B]	100-500	30-100	130-600	800	2,100	900	3,800	3,400	1,900
Selective[3/,B]	2,000-3,000	800-1,130	2,800-4,130						
Commercial Thinning[A]	3,000-4,500	2,500-3,500	5,500-8,000	5,200	5,400	7,100	8,000	13,600	2,500
Total Acres	**19,150-24,600**	**3,780-6,510**	**22,930-31,110**	**14,400**	**20,200**	**22,200**	**19,700**	**30,300**	**17,400**

PA = Preferred Alternative

1/ Taken from Table IV.15 in HCP (p. IV.211, DNR 1997), titled "Estimated amount of forest land management activities on DNR-managed lands in the area covered by the HCP during the first decade of the HCP."

2/ Activity types are taken directly from HCP (p. IV.204).

3/ Selective cuts include variable density thinnings

A. Characterized in the Draft EIS(DNR 2003) as a Type "A" harvest (Appendix B, p. B-43)

B. Characterized in the Draft EIS (DNR 2003) as a Type "B" harvest (Appendix B, p. B-43)

C. Characterized in the Draft EIS (DNR 2003) as a Type "C" harvest (Appendix B, p. B-43)

Data Source: DNR model outputs.

The evaluation of Alternatives in this analysis offers the 2001 rules package that provides measures necessary to address impacts due to road-related sedimentation (p. 3-16). These mitigation measures include implementation of road maintenance and abandonment plans and the adaptive management program. In addition, Appendix F in the Final EIS for the Forest Practices Rules discusses the effects of road construction and maintenance and describes recommended and accepted practices for building and maintaining roads. It states that, “Roads built following Forest Practices Rules that provide specific direction and recommended “best management practices” from the literature have the lowest risk of causing sediment delivery” (p. F-2). As stated above, all of the Alternatives will meet the requirements as specified in the Forest Practices Rules.

Soil Productivity

All soils data presented in Tables 4.6-5 and 4.6-6 are based on the DNR soils layer, which is based on the Private Forest Land Grading system and subsequent soil surveys completed

Table 4.6-5. Site Class, Compaction Potential, Fertilizer Response, and Burn Damage Potential by Land Classification (Percent Area)

Land Classification	Uplands with General Objectives	Riparian	Uplands with Specific Objectives	Average Westside
Moist Soil Compaction Potential				
High	70	67	59	64
Low	4	4	6	5
Medium	22	22	27	24
N/A	0	1	2	1
No Data	3	5	7	5
Variable	0	1	0	1
Fertilizer Response				
High	17	9	13	13
Low	34	19	9	18
Medium	23	15	15	17
No Data	26	56	63	51
Burn Damage Potential				
High	18	16	27	22
Low	48	49	34	42
Medium	30	28	30	29
N/A	1	2	2	2
No Data	3	5	7	5
Variable	0	0	0	0
Site Class (Site Index)				
I (143)	6	4	2	4
II (127)	44	30	21	30
III (109)	38	45	46	44
IV (89)	10	17	24	18
V (69)	2	4	8	5

Data Source: DNR Soils Layer.

Table 4.6-6. Site Class, Compaction Potential, Fertilizer Response, and Burn Damage Potential by Planning Unit (Percent Area)

	Percent Area by HCP Planning Unit						
	Columbia	**N. Puget**	**OESF[1/]**	**S. Coast**	**S. Puget**	**Straits**	**Westside**
Compaction Potential							
High	60	75	64	94	30	22	64
Low	1	3	No data	1	24	13	5
Medium	28	11	34	4	43	57	24
N/A	0	4	0	0	1	1	1
No Data	9	7	2	1	3	7	5
Variable	2	0	0	0	0	0	1
Fertilizer Response							
High	14	6	No data	3	29	62	13
Low	36	3	No data	57	11	1	18
Medium	27	18	0	16	26	24	17
No Data	23	72	100	24	34	12	51
Burn Damage Potential							
High	14	32	No data	3	60	43	22
Low	51	6	76	84	19	12	42
Medium	23	51	22	11	17	38	29
N/A	0	4	0	0	1	1	2
No Data	9	7	2	1	3	7	5
Variable	2	0	0	0	0	0	0
Site Class (Site Index)							
I (143)	3	4	1	10	1	0	0
II (127)	37	25	14	60	22	9	9
III (109)	38	40	61	28	49	57	57
IV (89)	18	20	21	2	25	30	30
V (69)	3	11	3	1	3	4	4

Data Source: DNR Soils Layer.
[1/] OESF = Olympic Experimental State Forest

in 1980. Each of the attributes of the data (displayed in Tables 4.6-2 and 4.6-3) has its own criteria that characterize soils as high, medium, or low "potential" for that category. Additional information (metadata for this dataset) can be found at http://www3.wadnr.gov/dnrapp6/dataweb/metadata/soils.htm.

Almost two-thirds of western Washington forested state trust lands can be characterized as having a high potential for soil compaction (Table 4.6-5). Additionally, almost half of the DNR-managed forested trust lands have been evaluated for response to fertilization. Of the lands evaluated, approximately 70 percent have a low-to-medium response rate to fertilization and only about 30 percent have a high response rate. While 42 percent of western Washington forested state trust lands have a low potential for burn damage, approximately 22 percent have a high potential.

SITE INDEX CLASSIFICATION

Site index is a measure of soil productivity, expressed as the height of the dominant trees in a stand at a given age. These indices are grouped into site classes (I through V), each of which corresponds with a range in tree heights. Class I corresponds with the tallest trees, and therefore generally the most productive soils. Class V corresponds with shorter trees, and therefore generally the least productive soils. Less than 5 percent of forested trust lands is classified as Class I (the most productive class) (Table 4.6-5). Throughout forested trust lands, most areas are classified in site classes II and III. Less than 5 percent is classified as Class V (the least productive class). This information is broken down by Habitat Conservation Plan planning unit in Table 4.6-6.

FERTILIZER RESPONSE AND SITE PREPARATION

Table 4.6-6 also shows the fertilizer response of soils on western Washington forested state trust lands where data are available. The fertilizer response of a given soil is the growth response of trees in that soil to a given application of fertilizer (nitrogen). Some forest soils allow a greater tree growth response than others to the application of fertilizer. The forested trust lands evaluated are approximately equally distributed among low, medium, and high for fertilizer response. Since 1993, between 2,251 and 20,944 acres of western Washington forested state trust lands were treated each year to increase productivity. As shown in Table 4.6-7, the maximum area that fertilizer was applied to in a given year was 10,811 acres. Since 2000, fertilizer use has decreased to approximately 300 acres per year of biosolid fertilizer application.

Acres of forested trust lands on which various site preparation methods were applied varied from 75 to 5,900 acres between 1993 and 2002 (Table 4-6.7). Since 1993, vegetation management techniques have been applied to a minimum of 2,176 acres in 1994 and a maximum of 13,305 acres in 2001.

Table 4.6-7. Area of Fertilization, Site Preparation, or Vegetation Management in Western Washington Forested State Trust Lands between 1993 and 2002 (acres)

Year Completed	Area Fertilized	Area of Site Preparation	Area of Vegetation Management	Total Area Treated
1993	<1	146	7,070	**7,216**
1994	<1	75	2,176	**2,251**
1995	20	165	4,478	**4,663**
1996	762	173	3,960	**4,895**
1997	711	1,130	7,329	**9,170**
1998	683	972	8,967	**10,622**
1999	10,811	1,699	8,434	**20,944**
2000	2,697	5,900	8,818	**17,415**
2001	366	4,993	13,305	**18,664**
2002	299	3,906	3,721	**7,926**

Data Source: DNR Planning and Tracking database.
Area fertilized includes both application of biosolids and aerial fertilizer application in North Puget and South Puget Habitat Conservation Plan Planning Units. Area fertilized updated from e-mail communication from Carol Thayer, 7/24/03.

4.6.4 Environmental Effects

Potential environmental impacts of the Alternatives on geomorphologic processes, sediment delivery, and soils are discussed in terms of changes to harvest levels and management. Effects on hydrology, water quality and fish are further discussed in Sections 4.7 (Hydrology), 4.8 (Water Quality), and 4.10 (Fish), respectively.

4.6.3.5 Comparison of Alternatives

Impacts to forest soils on western Washington forested state trust lands that may result from implementation of the various Alternatives are analyzed in terms of the potential for displacement and loss of soil through mass wasting, potential for changes in surface erosion, and potential for changes in soil productivity.

Common to all Alternatives is the existing and projected future roaded area on forested trust lands. All road maintenance and abandonment will be accomplished following 2001 Forest Practices Rules, and DNR policies and procedures for all Alternatives. Over the time period of this analysis, no significant differences in the rate of change, or total roaded area, are expected among the Alternatives (as discussed earlier in this section). In addition, changes in the practices related to road location or construction will occur independent of this action.

Mass Wasting

MANAGEMENT OF POTENTIALLY UNSTABLE SLOPES

No current policies or procedures would change under any of the Alternatives with respect to the management of potentially unstable slopes. Continued careful planning is necessary for all Alternatives, as discussed in Appendix C, Section C.4.

DNR is currently guided in the process of identifying, delineating, and managing potentially unstable slopes by the Habitat Conservation Plan (HCP) and the state Forest Practices Rules. In the HCP, DNR commits to not increase the frequency and severity of landsliding. Under the Forest Practices Rules, DNR is committed by law to assess the effects of harvest on defined landforms and site conditions prone to instability. In order to evaluate feasible mitigation options, DNR will assess risk for sales with slope stability concerns (see *Mitigation and Monitoring* below). In anticipation of Class IV special application classification under the Forest Practices Rules, DNR prepares geotechnical reports to address these issues as outlined under Washington Administrative Code (WAC) 222-10-030. A Class IV special permit is required when a timber sale is conducted on potentially unstable slopes or landforms that have the potential to deliver sediment or debris to a public resource, or that have the potential to threaten public safety (WAC 222-16-050(d)).

In managing forested trust lands, timber harvest activities, by their very nature, create disturbances to the soil and hydrologic processes through existing and new roads, landings, skid trails, slash burns, etc. It has been demonstrated that logging activities can generate sediment that, if delivered to the aquatic ecosystem in significant quantities, can degrade habitat for fish and other species.

DNR's obligations under the HCP are to conduct effectiveness monitoring for the riparian conservation strategy and determine how to harvest timber and meet conservation objectives by minimizing sediment runoff and attempting to prevent increases in the severity and frequency of landslides. The objective is to manage sediment inputs to levels that do not produce significant adverse effects on aquatic and terrestrial ecosystems. Because forest roads are a major source of sediment, DNR Forest Practices has published Best Management Practices in Section 3 of the Forest Practices Board Manual outlining in detail Best Management Practices for road construction, maintenance, and abandonment.

THE ALTERNATIVES

Relative landslide risk among the Alternatives is evaluated based on the intensity of management in upland areas where the potential for mass wasting exists, rather than an analysis of harvest projected to occur in unstable areas. This analysis approach was taken for two main reasons. There are uncertainties in the potential for mass wasting on forested trust lands in areas identified by the SMORPH model created by DNR Forest Practices to predict areas of high, medium, and low potential for slope instability, and very few known unstable slopes are currently mapped. In addition, DNR has not determined site-specific harvest locations. This Final Environmental Impact Statement (EIS) is an analysis of a non-project action, an evaluation of the policy implications of various sustainable harvest levels. Project level (e.g., individual timber sales) environmental analyses will assess site-specific factors during project design. For instance, project design decisions are made at the operational timber sale design level by foresters and geologists in the field; such actions are evaluated using the extended Environmental Checklist designed by the DNR to better analyze forest management.

Table 4.6-8 is used to help characterize the type of potential harvests on lands where unstable slopes are likely to occur. This is seen as a surrogate, appropriate for non-project analysis. The Uplands with Specific Objectives land class contains lands for which DNR manages a number of sensitive resources. These include, but are not limited to, northern spotted owl nesting, roosting, foraging, and dispersal habitat; rain-on-snow management areas; and potentially unstable slopes. The modeling process, however, does not retain specificity about where within the land class a specific resource is contained. Despite this, it is assumed for the purpose of this analysis that overall harvest in the land class by Alternative is a reasonable surrogate for, and is proportional to, the harvests that could actually occur in areas of potential slope instability.

In addition, harvests in the Uplands with Specific Objectives land class are reported by volume of timber per acre (low, medium, and high) that would be removed. In upland areas, it can be generally assumed that: 1) low-volume removal harvests will be light traditional thinnings, 2) medium-volume removal harvests will be heavy traditional thinnings, and 3) high-volume removal harvests will be regeneration harvests.

Table 4.6-8. Harvest in Uplands with Specific Objectives by Alternative

	Average Percent of Uplands with Specific Objectives by Area Impacted per Decade by Harvest Type			
Alternative	Low Volume Removal Harvest[1/]	Medium Volume Removal Harvest[2/]	High Volume Removal Harvest[3/]	Total
1	3%	<1%	5%	8%
2	4%	2%	10%	16%
3	4%	1%	11%	15%
4	5%	2%	5%	12%
5	12%	4%	11%	26%
PA	1%	2%	9%	12%

PA = Preferred Alternative
Data Source: Model output data – timber flow levels.
1/ Less than 11 thousand board feet per acre volume harvests
2/ Between 11 and 20 thousand board feet per acre volume harvests
3/ Greater than 20 thousand board feet per acre volume harvests

These generalizations, however, will vary some by Alternative depending upon the types of harvest being emphasized. For example, in the Preferred Alternative, biodiversity management harvests such as variable density thinnings and patch cuts could be either medium- or high-volume removal harvests, depending on the standing volume in that stand. In short, this analysis of differences among Alternatives in level of activity in areas that may contain potentially unstable slopes is appropriate only as a relative measure, and should not be mistaken as an analysis of potentially unstable slopes that will be harvested by each of the Alternatives if implemented.

Assuming that: 1) in areas with potential for mass wasting any decreases in root strength may contribute to landslide risk, and 2) regeneration harvest has a greater risk of triggering landslides than thinning in areas of slope instability, a partially grouped ranking of the proposed Alternatives from highest to lowest potential for increased risk associated with mass wasting (based on Table 4.6-8) is: Alternative 5 (highest); Alternatives 2 and 3 (intermediate high); the Preferred Alternative (intermediate); Alternative 4 (intermediate-low); and Alternative 1 (lowest).

All of the Alternatives may require mitigation and monitoring to ensure that obligations under Forest Practices Rules and the Habitat Conservation Plan are maintained. The procedure for assessing slope stability would not change under any of the Alternatives. However, the level of resources necessary to assess risk, and conduct monitoring and other types of mitigation would increase under Alternatives 2, 3, 5, and the Preferred Alternative, compared to Alternatives 1 and 4, due to their increased levels of proposed activities in potentially unstable areas.

MITIGATION AND MONITORING

The riparian conservation strategy for the five Westside HCP Planning Units (excluding the Olympic Experimental State Forest) had several objectives, including mitigating potential effects of landslides on the aquatic ecosystem. Slope geomorphologic models, landslide history, and information on soils and geology will continue to be used to identify landslide prone areas. The DNR procedure for assessing slope stability

(PR 14-004-050) requires field verification of potential mass wasting with qualified staff. During field reconnaissance, site data are gathered on a variety of factors, including the nature of the geology (soils and rock), size of effected area, slope, and hydrologic conditions. Potential downslope effects on various resources and public safety may also be evaluated as appropriate based on site factors, including loss of fish habitat for listed species; loss of downslope timber values; domestic water use; and developments such as highways, houses, pipelines, etc. Currently, DNR conducts qualitative risk analyses of harvest activities on potentially unstable ground on a timber-sale-by-timber-sale basis.

Mitigation of slope and soil disturbance may include alternative operational techniques such as intermediate suspension, contract requirements for full suspension, or helicopter harvest (which would have the added benefit of limiting or eliminating road construction). Mitigation also may include sale boundary layout to avoid areas of instability where operational techniques are determined to be unsuccessful in preventing mass wasting or surface erosion. Where groundwater recharge may contribute to slope instability, reduced harvest densities may be applied. Existing roads will be maintained or abandoned under the stringent road maintenance and abandonment provisions of the Forest Practices Rules. New roads will be constructed following requirements of the Forest Practices Rules.

Implementation monitoring of managed land is ongoing. A pilot project has been completed examining the evaluation of slope stability in timber sale planning and to establish a baseline for testing the effectiveness of associated mitigation recommendations. Annually, a report is submitted to the National Oceanic and Atmospheric Administration Fisheries and U.S. Fish and Wildlife Service (Federal Services), which has in past years included levels of compliance with unstable slopes management requirements under the riparian conservation strategy contained in the Habitat Conservation Plan (HCP).

Long-term effectiveness monitoring will be implemented to measure sediment delivery from roads and harvest activities. Monitoring may include some of the following elements.

Best Management Practices can be evaluated using paired studies on site or road segment scale to measure impacts on the aquatic ecosystem. Where there are no public resources at risk, paired studies can be used to test various thinning methods in order to determine if harvests can be conducted on moderate- to low-risk landslide-prone areas. The research findings will then be integrated into the ongoing implementation of the HCP. DNR is in the process of developing these studies at this time.

If monitoring demonstrates that landslide frequency or severity may be increasing under current policies, modifications to harvest plans will be made, and harvest may be reduced accordingly. Based on results, the assumption would likely be made that greater amounts of land disturbance, and greater areas of more intense disturbance, will increase the potential for landslide risk that will need to be addressed. Potential increases to landslide risk can be addressed either with reduced harvest, modifications to proposed harvest methods, or other mitigation that would depend on the information gathered from monitoring and site conditions.

Monitoring and reporting will also be done for the Board of Natural Resources. On March 2nd, 2004, the Board of Natural Resources passed Resolution No. 1110, which authorizes the DNR to prepare the Final Environmental Impact Statement for Sustainable Forest Management of State Trust Lands in Western Washington. Section 4 (L) of the resolution states: “The Department shall annually report to the Board of Natural Resources its assessment of the environmental and economic results of implementing the Preferred Alternative. The Department shall employ a structured monitoring and reporting program.”

Surface Erosion

Road use is assumed to be a function of the amount of timber hauled. Effects from public road use for recreation and other public use of forested trust lands are expected to be constant for all Alternatives. Higher timber volumes can be assumed to require more truck trips and, therefore, potentially increase the contribution of surface erosion caused by roads. Specifically, Alternative 5, with the highest levels of management intensity by acreage, would be expected to require more planning and maintenance to appropriately address surface erosion, followed by Alternatives 3 and 2; the Preferred Alternative; and Alternatives 1 and 4. For levels of logging traffic by Alternative, see the discussion of Transportation Infrastructure in Chapter 4, Section 4.11.4. Sediment delivery to streams is discussed in Section 4.7 (Hydrology), Section 4.8 (Water Quality), and Section 4.10 (Fish). Due to implementation of DNR’s Habitat Conservation Plan (HCP) and requirements for Road Maintenance and Abandonment Plans under the Forest Practices Rules, it is expected that substantial improvements in road management and surface erosion will continue into the future. No significant adverse impacts to surface erosion beyond those anticipated under the HCP Environmental Impact Statement (EIS) or Forest Practices Rules EIS are expected under any of the Alternatives.

Soil Productivity

The goal of successful sustainable forest management is to meet conservation objectives and fiduciary responsibilities without degradation of soil. Intergeneration equity requires actions that protect and maintain current and future forest functions (Burger and Kelting 1998). For this reason, soil conservation and maintenance or improvement of soil productivity should be inherent qualities of sustainable forest management. If site productivity declines appreciably, the harvestable timber volume per acre may decline over time. If this were to happen, the risk of not meeting all sustainable forest management goals would increase.

Factors that may influence soil productivity among the Alternatives are management strategies, and management intensity. See Chapter 2 and Appendix C for a description of the variations in these parameters among Alternatives. In general, more intensive management may lead to a greater risk of soil compaction and surface erosion. As shown in Table D-4, Alternative 5 has the highest levels of management intensity and total harvest area and would be expected to have the highest risk of potentially decreasing soil productivity, followed by Alternatives 3 and 2; the Preferred Alternative; and Alternatives 4 and 1. Alternatives 3 and 2 have similar, relatively high levels of both high-volume harvest and total harvest. The Preferred Alternative has less total disturbance than Alternatives 3 and 2 but a similar amount of high-volume harvest. Alternatives 4 and 1 have less high-volume harvest than the other Alternatives, with Alternative 1 having the lowest high-volume and total harvest. However, the increased use of fertilizers for

Alternatives 5 and the Preferred Alternative may mitigate potential losses of productivity due to increased management intensity, except for soil compaction. When designing and implementing harvest activities on highly compatible soils, locations of skid trails can be carefully planned by foresters in the process of setting up timber sales, and appropriate yarding techniques should be used to prevent or minimize compaction.

Chapter 4

4.7 HYDROLOGY

4.7.1 Summary of Effects

This section analyzes the environmental effects on hydrology. The analysis examines the potential effects of proposed changes to policy and procedures and uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

Procedure 14-004-060, which prohibits harvest of hydrologically mature forest in the rain-on-snow and snow zones where the mature forest type makes up less than 66 percent of these zones, would not change under any of the Alternatives. Consequently, significant changes in peak flows due to harvest activities would continue to be avoided under all of the Alternatives. The Habitat Conservation Plan Environmental Impact Statement (DNR 1996) provides more detailed analyses of the effectiveness of the measures laid out in Procedure 14-004-060 and other procedures in minimizing potential adverse effects to peak flows from harvest activities (see Sections 4.2.3, 4.4.3, and 4.8).

4.7.2 Introduction

The hydrology of a watershed includes the amount, intensity, and timing of water movement. Watershed hydrology is affected by climate, vegetation, other physical and biological factors, and watershed management. Changes in peak flows, or the highest expected volume of surface water flowing in a stream, can affect streambank stability and channel morphology, water quality, salmonid habitat, sensitive plant species, and the built environment (via flooding). Peak flows, which can become large floods, can adversely affect public safety and infrastructure.

During scoping, the main issue for hydrologic resources was identified as peak flows. Forest management can affect runoff and subsurface stormflow, and therefore change the timing and magnitude of peak flows through timber harvest and road construction (Section 3.3 of the Forest Practices Rules Environmental Impact Statement, pages 3-27 through 3-33 [Washington Forest Practices Board 2001] and Section 4.8 of the Habitat Conservation Plan Environmental Impact Statement, pages 4-509 through 4-524 [DNR 1996]). The amount and location of roads and timber harvest can affect the timing and quantity of runoff, subsurface stormflow, and peak flows. Soil compaction, such as may result from the operation of heavy machinery on some soil types, can reduce soil permeability, thereby contributing to peak surface water flows.

4.7.3 Affected Environment

Much of the information presented in this section is drawn from the Draft and Final Habitat Conservation Plan (HCP) Environmental Impact Statement (EIS) (pages 4-139 through 4-180, 4-243 through 4-305, 4-509 through 4-524, and Glossary page 6 [DNR 1996] and the Forest Practices Rules EIS (pages 3-27 through 3-33, Washington Forest Practices Board 2001). Refer to these documents for additional information related to hydrological effects on the environment.

The principal influences on surface water movement are climate, soils, geology, topography, and vegetation (Section 3.3 of the Forest Practices Rules EIS, pages 3-27 through 3-33 [Washington Forest Practices Board 2001]). Precipitation is controlled by climate and is not significantly influenced by forests or their management. Loss of water to the atmosphere by evaporation and transpiration of plants can be influenced by forest management. Water movement in natural streams is a function of water volume, channel geometry, and channel slope or gradient. In unmanaged forest areas, the most common disturbance to stream hydrology is trees and other vegetation entering streams. In places where this debris is temporarily stabilized, it influences sediment storage, hydraulics, and channel morphology (Montgomery et al. 2003).

4.7.3.1 Existing Conditions on Western Washington Forested State Trust Lands

For the purposes of this analysis, water Types 1 through 4 were identified. Stream types were updated for the model to better estimate the amount of fish-bearing streams on the forested trust lands based on DNR field foresters' reports and other known studies (Bahls and Ereth 1994, DNR 1995, Mobbs and Jones 1995). All waters originally mapped as Type 5 and all streams of unknown classification (Type 9) were grouped into Type 4. All Type 4 streams were reclassified as Type 3 streams. Streams originally classified as Types 1, 2, and 3 were kept in their respective categories. As a result, stream miles by type (as displayed in Table 4.7-1) do not match those referenced in the Habitat Conservation Plan (HCP) Environmental Impact Statement (EIS) (DNR 1996, page 4-250).

Based on this water typing system, nearly 70 percent of streams in western Washington are classified as non-fish-bearing, Type 4 streams (Table 4.7-1). Relatively few are rated high quality for beneficial uses. Approximately 5 percent of streams in the region are classified as Type 1 or 2. Less than 30 percent are Type 3 streams.

The largest peak flows in western Washington occur after rain-on-snow events (rainstorms that partially or completely melt snowpacks). The significant rain-on-snow zones (generally defined as an elevation zone) are where rain-on-snow events occur several times during the winter, typically at elevations of 1,000 to 3,000 feet above sea level. During rain-on-snow events, rainfall saturates existing snowpacks and causes rapid melting, leading to large volumes of runoff during relatively short periods of time. See Section 3.3 of Forest Practices Rules EIS (Washington Forest Practices Board 2001).

These events reach their greatest magnitude on forested lands in hydrologically immature forests (i.e., young trees), where the lack of a dense canopy allows greater snow accumulation and subsequent rapid melting (Washington Forest Practices Board 2001, Section 3.3, pages 3-29 through 31). In contrast, hydrologically mature stands approach the hydrologic processes and outputs (e.g., water yield, peak flows) expected in a mature stand under the same climatic and site conditions. Hydrologically mature forests are defined in the HCP as well-stocked conifer stands at 25 years or older (DNR 1996, Glossary, page 6). Snow accumulation and rate of melt are generally slower in hydrologically mature forests.

Table 4.7-1. Lengths of Streams on Forested Trust Lands by Stream Type and HCP Planning Unit

HCP Planning Unit	Length of Streams (miles)				Total
	Type 1	Type 2	Type 3	Type 4	
Columbia	101	7	715	2,519	**3,343**
North Puget	154	52	1,144	1,744	**3,093**
Olympic Experimental State Forest	156	55	816	1,772	**2,799**
South Coast	78	25	711	2,102	**2,915**
South Puget	41	14	271	845	**1,171**
Straits	21	17	210	383	**631**
Total	**551**	**170**	**3,867**	**9,364**	**13,952**

Data Source: DNR hydro layer data.

Hydrologically immature forests within significant rain-on-snow/sub-basin zones (i.e., those areas managed for rain-on-snow according to DNR Procedure 14-004-060) cover approximately 20 percent of the DNR-managed forested trust lands (Table 4.7-2). The data presented in Table 4.7.2 provide a general characterization of the current hydrologic maturity of the forested trust lands. In addition, rain-on-snow zones in many of these watersheds also include land classified as non-forested. Peak flows have the potential to be greater in non-forested areas than in forested areas in rain-on-snow zones.

Section 4.15, Cumulative Effects, provides additional information on the status of hydrologic maturity and on the sensitivity of the Alternatives, organized by individual watersheds.

4.7.4 Environmental Effects

4.7.4.1 Comparison of Alternatives

Procedure 14-004-060, which prohibits harvest of hydrologically mature forest in rain-on-snow and snow zones where the mature forest type makes up less than 66 percent of these zones, would not change under any of the Alternatives. Consequently, significant changes in peak flows due to harvest activities would continue to be avoided under all of the Alternatives. The Habitat Conservation Plan (HCP) Environmental Impact Statement (EIS) (DNR 1996) provides more detailed analyses of the effectiveness of the measures laid out in Procedure 14-004-060 and other procedures in minimizing potential adverse effects to peak flows from harvest activities (see Sections 4.2.3, 4.4.2, and 4.8, pages 4-139 through 4-180, 4-243 through 4-305, and 4-509 through 4-524). For this analysis, new road construction is assumed to be similar under all Alternatives. Consequently, the impacts from the road network would be essentially the same under all Alternatives (see Section 4.6).

Table 4.7-2. Areas of Hydrologic Maturity and Immaturity in Significant Rain-on-Snow/Sub-Basin Zones by Westside HCP Planning Unit (Current 2004)

HCP Planning Unit	Hydrologically Mature Forest in Rain-on-Snow Zones		Hydrologically Immature Forest in Rain-on-Snow Zones		Total Forest in Rain-on-Snow Zones (Acres)
	Acres	Percent	Acres	Percent	
Columbia	56,979	77	16,849	23	**73,828**
North Puget	62,541	84	11,685	16	**74,226**
OESF[1/]	20,988	58	15,205	42	**36,193**
South Coast	6,257	98	125	2	**6,382**
South Puget	36,710	86	5,734	14	**42,444**
Straits	2,998	97	87	3	**3,084**
Total	**186,474**	**79**	**49,684**	**21**	**236,157**

Data Source: DNR GIS overlay data.
[1/] OESF = Olympic Experimental State Forest

The potential for any of the Alternatives to result in significant adverse impacts to peak flows, therefore, would most likely result from soil compaction associated with timber harvest activities in riparian areas.

Under Alternative 1 (No Action), timber harvest would not be allowed in riparian areas except for access development (i.e., roads and yarding corridors). Therefore, no change in peak flows would be expected under this Alternative.

The impacts of Alternatives 2 and 3 with respect to changes in riparian procedures would be minor and would not affect peak flows. Over the long term, harvest in the middle and outer zones would result in more diverse stand conditions, which may mitigate potential peak flows.

Alternative 4 would not change the restrictions on allowable activities in Riparian Management Zones. No additional impact on peak flows would be anticipated under Alternative 4, compared to Alternative 1 (No Action).

Alternative 5 would allow more harvest in Riparian Management Zones than Alternatives 1, 2, 3, or 4. If ground-based yarding were implemented in these riparian areas, small areas within the Riparian Management Zones would be compacted, which could result in relatively small, highly localized, short-term increases in peak flows. Given the dynamic nature of hydrologic regimes, these changes to peak flows would not likely be detectable at a watershed scale.

The Preferred Alternative would allow moderate harvest activities within riparian areas than the other Alternatives. The area of disturbance in the Riparian land classification is estimated to be similar to Alternative 5, but there would be greater amount of variable density thinning and patch cuts in these areas (see high volume removal harvest column in Table 4.2-15). Depending on yarding methods, this Alternative could affect localized peak flows. Yarding systems that suspend logs, such as helicopter and cable with full suspension, would not cause soil compaction, and would therefore not affect peak flows. However, if ground-based yarding were implemented at the proposed rate, sufficient soil compaction may occur in some areas to cause localized increases in peak flows. Similar to Alternative 5, short-term localized increases would not likely be detectable at the watershed scale.

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4.8 WATER QUALITY

4.8.1 Summary of Effects

This section analyzes the environmental effects on water quality, and examines the current policy and procedures and the prospective changes. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts of the Alternatives. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

None of the Alternatives would increase the risk of water quality degradation in the long term. Existing procedures adequately protect water resources. Short-term, localized sedimentation may increase in some areas immediately following harvest, but the vegetation in the inner and no-harvest portion of the Riparian Management Zones would prevent most sediment from entering streams. Over the long term, improved riparian function would likely lead to improved water quality on DNR forested trust lands.

In the short term, additional planning and implementation resources would be required to prevent sediment delivery to streams as a function of greater harvest in the Riparian Management Zones under Alternatives 2 and 3, and, to a greater extent, under Alternative 5 and the Preferred Alternative. However, in the long term, riparian function across the land base is expected to improve more rapidly under the Preferred Alternative than any other Alternative proposed, as discussed in Section 4.3 (Riparian).

4.8.2 Introduction

Water quality is a function of several variables, including sediment input, organic input, hydrology, levels of contaminants (including forest chemicals such as pesticides, herbicides, and fertilizers), and temperature. Each of these variables is dependent upon several factors, including local weather and climate, stream morphology, sources of erosion, levels of chemical use and pathways for migration of contaminants, filtering and binding capacity for contaminants of vegetation and organic material, and amounts and types of vegetation near streams.

Streams at lower elevations are likely to have higher temperatures than streams at high elevations. However, groundwater discharge may regulate temperature in smaller streams. Shading provided by vegetation helps maintain low water temperatures. Stream temperature may rise as a result of timber harvest in areas adjacent to streams due to effects of increased solar radiation. The link between stream temperature and upslope clearcuts is less certain. Finally, vegetation in riparian areas and in the watershed in general can reduce sediment input and overland flow of water, reducing peak flows, as discussed in Section 4.7, Hydrology. See also Section 3.6 of the Forest Practices Rules Final Environmental Impact Statement (Washington Forest Practices Board 2001).

Good water quality enables beneficial uses, such as fish habitat and recreation. The main issue identified for water quality during scoping was the potential adverse effects to water quality caused by forest management activities. Specifically, increases in-stream water temperature and sediment delivery to streams and the introduction of forest chemicals (i.e., pesticides, herbicides, and fertilizers) to the aquatic environment were identified as key issues. Changes to these parameters can affect aquatic habitat, recreation, and other beneficial uses.

4.8.3 Affected Environment

This section draws on the discussion in the Habitat Conservation Plan Environmental Impact Statement (DNR 1996) and Forest Practices Rules Environmental Impact Statement (Washington Forest Practices Board 2001) to describe the regulatory background and water quality conditions in western Washington. Refer to these documents for additional information related to water quality effects on the environment.

Temperature

Surface water temperature plays an integral role in the biological productivity of streams. Section 3.6 of the Forest Practices Rules Environmental Impact Statement (Washington Forest Practices Board 2001), as well as other recent studies (Sidhar et al. 2004; Bartholow 2000; Johnson and Jones 2000), described how the temperature of surface water is modified by forest management. Streamside vegetation prevents extreme daily fluctuation in temperature during low flows and high solar energy input by providing shade and absorbing energy. Dissolved oxygen concentrations are higher with lower temperatures, which benefits many aquatic biota. Low stream temperatures are critical for the survival of various fish species. When changes in water temperature occur as a result of timber harvesting, they are typically noted in small rivers and streams.

Sediment

Sedimentation accounts for significant water quality deterioration in forested lands in the state of Washington (Section 4.8, page 4-509, Habitat Conservation Plan Environmental Impact Statement [DNR 1996]). Sediment affects water quality in several ways. It creates a muddy (turbid) condition that restricts light in the stream environment. Nutrients combined with, or attached to, the sediment particles are added to surface water. Oxygen-demanding materials associated with sediment can reduce dissolved oxygen content. Sedimentation may also introduce harmful minerals and chemicals into surface water. Biological effects of increased turbidity may include a decrease in primary productivity of algae and periphyton because of decreased light penetration. Declines in primary productivity can adversely affect the productivity of higher trophic levels such as macroinvertebrates and fish. Siltation and turbidity have also been shown to affect fish adversely at every stage in their life cycle.

The amount of sediment that reaches a stream depends primarily on two processes: the availability of sediment and the ability of sediment to travel from its source to the stream. Sediment is produced through mass wasting and surface erosion, as described in Section 4.6, Geomorphology, Soils, and Sediment, and in Section 4.15, Cumulative Effects.

The ability of sediment to travel from its source to streams could be affected through changes in harvest in riparian areas. In general, the vegetation in riparian areas serves as a filter, removing sediment before it reaches a water body. In most cases, vegetation immediately adjacent to a stream channel is most important in maintaining bank integrity (Forest Ecosystem Management Assessment Team 1993). Protection of streambank integrity and adequate soil filtering of surface erosion is generally maintained with a fully functioning stand within 30 feet of a stream.

Forest Chemicals

Chemicals used in forest management include a variety of herbicides, fertilizers, and pesticides introduced to the forest environment to control or halt the proliferation of nuisance organisms or to improve soil productivity. Fertilizers used between 1993 and 2002 in the region include urea (aerial applications) and biosolids (ground applications). The following herbicides were also applied (aerially and by ground application): 2,4-D Ester, Accord, Arsenal, Garlon 4, Oust, Roundup, Transline, and Velpar L. Chemicals used in the forest environment can become water contaminants if they are transported to surface waters (or groundwater). They can also be directly applied to surface waters by overspray and spills. Contamination usually results from the lack of spray buffers or from applications over dry or ephemeral streams.

According to DNR records, between 1993 and 2002, herbicides were applied to approximately 70,000 acres within DNR-managed forested trust lands (Table 4.8-1). Ground applications of herbicides were applied in every HCP Planning Unit, while aerial applications occurred in all areas except the Olympic Experimental State Forest and the Straits HCP Planning Unit. Fertilization applications were less common, with aerial fertilization occurring only in the North Puget HCP Planning Unit. Ground fertilization occurred only in the North Puget HCP Planning Unit and, to a very limited extent, in the South Puget HCP Planning Unit (less than 100 acres).

Pesticide application rates on forested trust lands were infrequent (one to two applications every 40 to 60 years). Less than 5 percent of forested trust lands have been treated with chemicals during the last decade. This 10-year application history suggests that herbicides are the most common forest chemicals applied in the forested trust lands. These relative levels of use are likely to continue into the future.

Several monitoring studies designed to evaluate the effects to water quality from fertilization applications in western Washington and similar nearby forested lands have been conducted (Bisson 1988; Cline 1973; Moore 1974; McCall 1970; Ryan 1984; Ryan and Donda 1989). In general, the results of these studies show that significant short-term increases of urea, ammonia, nitrate, nitrite, and phosphorus typically following applications of urea and phosphorus-rich fertilizer. However, none of these studies found concentrations that exceeded water quality standards. Likewise, accelerated eutrophication (water pollution caused by excessive plant nutrients), which can lead to oxygen depletion, was not detected. Similarly, concentrations generally returned to pre-fertilization levels within 40 days (McCall 1970; Ryan and Donda 1989). Relatively large, localized increases were attributed to aerial fertilizer applications directly into tributary streams (Ryan 1984; Bisson 1988). Large precipitation events are correlated with increased nitrates measured in streams, caused by flushing of forested soils and delivery of chemicals to streams in storm runoff (Perrin 1976).

Table 4.8-1. Extent of Fertilization (Aerial and Ground) and Herbicide Application (Aerial and Ground) by Year in Forested Trust Lands

Year Completed	Area of Aerial Fertilization (Acres)	Area of Aerial Herbicides (Acres)	Area of Ground Fertilization (Acres)	Area of Ground Herbicides (Acres)	Total Area Treated (Acres)
1993	<1	1,449	<1	5,766	**7,215**
1994	<1	685	<1	1,491	**2,176**
1995	<1	1,436	<1	3,041	**4,478**
1996	<1	1,096	368	2,864	**4,328**
1997	20	2,874	381	2,926	**6,201**
1998	82	2,778	278	4,586	**7,724**
1999	2,888	3,882	456	2,946	**10,172**
2000	2,405	4,384	186	2,627	**9,602**
2001	<1	6,062	366	4,126	**10,554**
2002	<1	2,483	299	1,838	**4,620**
Total	**5,396**	**27,130**	**2,334**	**32,211**	**67,070**

Source: DNR Planning and Tracking database and e-mail communication from Carol Thayer, 7/24/03. Fertilization occurred in North Puget and South Puget HCP Planning Units.

Contaminants, such as fertilizers or herbicides that reach forest streams, can be flushed into larger water bodies. Some of these contaminants may be broken down by natural processes, such as ultraviolet radiation or digestion by organisms. In general, sufficient levels of increased nutrients can cause algae blooms in lakes and stagnant water bodies, causing eutrophication and resulting decreases in dissolved oxygen, potentially harming fish. Dissolved oxygen levels are further addressed with respect to forested trust lands in Section 4.10 (Fish) and Section 4.15 (Cumulative Effects).

Groundwater

Groundwater includes all water below the ground surface. Groundwater is not as sensitive to water quality degradation from forest management as surface water. In general, the quality of groundwater in aquifers depends more on aquifer and local geology than on forest influences. Activities in forest watersheds can affect groundwater quality, if they cover a large proportion of the watershed, and depending on the type and timing of the activity. See Section 4.8 of the Habitat Conservation Plan Environmental Impact Statement (DNR 1996) and Section 3.6 of the Forest Practices Rules Environmental Impact Statement (Washington Forest Practices Board 2001).

Subsurface flows, an important component of groundwater, are sensitive to immediate precipitation. Applying forest chemicals, for example, immediately prior to a rainstorm would increase the probability of degrading groundwater quality, if a sufficient portion of the watershed were treated. Groundwater contamination by forest chemicals can also occur through contaminated surface water recharge. As a result of the natural soil filters, groundwater recharged from forestland is generally of good quality.

4.8.3.2 Existing Water Quality

The Washington State Forest Practices Rules comply with the Clean Water Act to meet state water quality standards for surface waters and groundwater (Table 4.8-2). Water quality standards are set to provide for the protection of designated uses, including public water supply; wildlife habitat; and salmon spawning, rearing, and migration.

Section 303(d) of the federal Clean Water Act requires the state of Washington periodically to prepare a list of all surface waters in the state for which beneficial uses of the water are impaired by pollutants. As of 1998, about 2 percent of all the waters in Washington were identified as impaired. Segments of almost 250 streams were listed in western Washington in 1998 (see Appendix D). It is possible that other unmeasured water bodies also exceed water quality standards.

Table 4.8-2. Washington State Water Quality Standards for the Major Non-Chemical Parameters of Concern[1/]

Water Quality Parameter	Washington State Standard (Class AA, Excellent)	Washington State Standard (Class A, Good)
Temperature	Shall not exceed 16.0°C due to human activities. When natural conditions exceed 16°C, no temperature increase greater than 0.3°C is allowed. Incremental temperature changes from nonpoint source activities shall not exceed 2.8°C.	Shall not exceed 18.0°C due to human activities. When natural conditions exceed 18°C, no temperature increase greater than 0.3°C is allowed. Incremental temperature changes from nonpoint source activities shall not exceed 2.8°C.
Sediment	In regard to forest practices, implementation of approved Best Management Practices will meet narrative water quality criteria such as support characteristic water uses, aesthetic values, etc.	Same as Class AA.
Turbidity[2/]	Shall not exceed 5 nephelometric turbidity units (NTUs) over background when the background level is 50 NTUs or less, nor increase more than 10% of background when the background level is 50 NTUs or more.	Same as Class AA.

1/ New water quality standards have been proposed and are currently in a draft status. The new standards for temperature would be lower and more specific to fish populations (Department of Ecology 2003).

2/ Nephelometric turbidity units are the measurement units of turbidity using a nephelometer (light reflected surfaces of particles in suspension that are at right angles to the light source). 0 NTUs is clear and free of particles. >999 NTUs is essentially opaque.

NTU = nephelometric turbidity unit

Data Source: Forest Practices Rules Environmental Impact Statement (Washington Forest Practices Board 2001).

As stated in Section 4.8, page 4-509 of the Habitat Conservation Plan Environmental Impact Statement (DNR 1996), in general, the forests in western Washington contain waters of high quality. The primary water quality problem on forestlands throughout the state is temperature. Elevated water temperature generally occurs in areas where timber harvest or development has removed trees adjacent to rivers and streams, taking away shade, which is necessary to keep the water temperature low and healthy for fish. Other problems include erosion from road-building, construction, and agriculture, which increases sediment in streams (Forest Practices Rules Final Environmental Impact Statement, Section 3.6, page 3-106). A discussion of temperature and water quality problems on forested trust lands is also included in Section 4.15 (Cumulative Effects).

4.8.4 Environmental Effects

4.8.4.1 Comparison of Alternatives

Temperature

Stream temperature can be affected by the amount of shade provided by streamside vegetation. The Alternatives differ with respect to the level of harvest within the Riparian Management Zones. Refer to Section 4.3.4 (Riparian Environmental Effects) for details on the potential effects of the proposed Alternatives on stream shading. As described in that section, shade levels would generally improve under all Alternatives because all Alternatives would have a 25-foot no-harvest buffer, and would allow less harvest in the remainder of the Riparian Management Zone than allowed prior to implementation of the Habitat Conservation Plan riparian strategies. More large trees would develop (at differing amounts) under all Alternatives compared with current conditions. Improved shade levels would result in decreased stream temperatures, which would benefit most aquatic biota in these streams. Differences among the Alternatives in the amount of harvest allowed in Riparian Management Zones would lead to variations in anticipated effects on stream temperature. Relative to Alternative 1, some short-term reduction in shade may result from the removal of riparian trees under Alternatives 2, 3, 5, and the Preferred Alternative. However, across the land base, fully functioning riparian conditions, including increased shade in riparian areas from large trees, and therefore temperature reductions, would be expected more rapidly (80 to 90 years) with the Preferred Alternative than with the other Alternatives.

Sediment

Increased harvest would increase the risk of surface erosion from road use and other harvest-related activities, as well as the risk of mass wasting. The risk of sediment delivery to streams from surface erosion and mass wasting would be mitigated both by the use of existing policies and procedures, including appropriate road Best Management Practices, as well as the conservation of riparian sediment filtering functions, as discussed below and in the Riparian Section (4.3). The risk of sediment delivery from mass wasting would also be mitigated by existing policies and procedures and monitoring, as discussed in Section 4.6.4. Other than restoration activities, roads, and yarding corridors, none of the Alternatives proposes activities within the 25-foot no-harvest zone. The adjoining 75 feet is the minimal harvest zone that would include restricted activities that vary among Alternatives. This level of Riparian Management Zone protection reduces the differences in sediment delivery among Alternatives. Under Alternatives 1 and 4, the current riparian procedures would continue to be implemented and only riparian and stream restoration work and access development (roads and yarding corridors) would be allowed in Riparian Management Zones. These Alternatives would result in the same levels of sediment production described under current conditions and would not affect the filtering capacity of the Riparian Management Zone.

Alternatives 2 and 3 would allow more harvest in Riparian Management Zones and upland areas than Alternatives 1 and 4. The additional harvest in Alternatives 2 and 3 may lead to minor, localized increases in sediment caused by ground-based logging or, to a lesser extent, cable yarding and other ground disturbances. The increase in associated activities, such as road travel, could also contribute to the potential for increases in surface erosion. Surface erosion would be mitigated through the implementation of appropriate practices under these Alternatives. As a result, sediment production would not be significantly different from Alternatives 1 and 4.

Alternative 5 and the Preferred Alternative would involve increased management and, therefore, increased risk of surface erosion compared to Alternatives 1, 2, 3, and 4. The additional harvest modeled under Alternative 5 the Preferred Alternative may lead to minor, localized increases in sediment. Additionally, the increase in associated activities could also contribute to the potential for increases in surface erosion. The surface erosion would be mitigated through the implementation of appropriate policies and procedures under these Alternatives. The impacts that Alternative 5 and the Preferred Alternative would have on sediment delivery would likely be relatively minor as long as the no-harvest inner zone remains in place to filter sediment.

The Preferred Alternative proposes management levels by area across all land classes greater only than Alternative 1, the Alternative with the lowest overall management level. The Preferred Alternative however, proposes higher levels of management activities in riparian areas than is proposed under any of the other Alternatives, with most activities being high volume removals. Total area disturbance in the Riparian land class would be similar to Alternative 5 (Table 4.2-15). However, most of the disturbance would be from heavy thinnings designed to speed the development of structurally complex forest, while under Alternative 5, most disturbance in riparian areas would be as a result of light thinnings. Similar to Alternative 5, minor, localized and short-term sediment increases would be expected following harvest in these areas. The potential for surface erosion would be mitigated through the implementation of appropriate policies and procedures under this Alternative. The impacts that the Preferred Alternative and Alternative 5 would have on sediment delivery would likely be relatively minor as long as the no-harvest inner zone remains in place to filter sediment, and road-related Best Management Practices are functional and appropriate.

The potential for blowdown in Riparian Management Zones could be slightly greater than Alternative 5, because of increased levels of variable density thinning and patch cuts in the Riparian Management Zones. If blowdown occurs, root balls could be dislodged, leading to increased sediment. Potential adverse effects from increased harvest levels would be mitigated by using appropriate harvest and reforestation methods to prevent surface erosion, and by the riparian no harvest zone. However, openings greater than 1 acre can increase the risk of blowdown, which could affect the inner zone (Carey et al. 1996).

In the short term, additional planning and implementation resources would be required to prevent sediment delivery to streams as a function of greater harvest in the Riparian

Management Zones under Alternatives 2 and 3, and, to a greater extent, under Alternative 5 and the Preferred Alternative. However, in the long term, riparian function across the land base is expected to improve more rapidly under the Preferred Alternative than any other Alternative proposed, as discussed in Section 4.3 (Riparian).

Forest Chemicals

Fertilization levels would also differ under the Alternatives (Table 4.8-3). Alternatives 1, 2, 3, and 4, would include little to no fertilization. Alternative 5 would involve increased management intensity and would include fertilization treatments. The Preferred Alternative would include fertilization, but less frequently than under Alternative 5. Despite the relative differences in fertilization, these Alternatives would be consistent with existing forest policies and procedures, described in the Habitat Conservation Plan and Forest Practices Rules Environmental Impact Statement.

These policies and related mitigation measures were established, in part, to protect water quality. For example, mitigation measures exist to reduce the likelihood of accidental aerial applications directly to streams, the leading cause of water quality degradation from forest chemicals (see Appendix C for a discussion of policies and procedures). As a result, none of the Alternatives would likely result in significant adverse effects to water quality caused by forest chemicals.

Table 4.8-3. Fertilization Intensity by Alternative

Approach to Fertilization	Alternatives					
	1	2	3	4	5	PA
Little or none	X	X	X	X		
Available for specific forest types and sites					X	
Budget-limited for specific forest types and sites						X

PA = Preferred Alternative

4.9 WETLANDS

4.9.1 Summary of Effects

This section analyzes the environmental effects on wetland resources. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

DNR Forest Resource Plan Policy No. 21 states, "the Department will allow no overall net loss of naturally occurring wetland acreage and function." The procedure (PR 14-004-110 Wetland Management) governs harvest activities in and around wetlands and is not proposed to change under the Alternatives.

The approximate delineation method, an approved approach to determine wetland boundaries, primarily uses maps and aerial photographs. However, not all wetlands, particularly forested wetlands, are visible on aerial photographs. Also, the Habitat Conservation Plan and its Environmental Impact Statement acknowledges that wetlands less than 0.25 acre may be affected by forest management activities. Thus, the difference in environmental impacts to wetlands under the proposed Alternatives would be a function of the acreage to be harvested and the amount of related activities under each Alternative. Over all, Alternative 1 would result in the lowest level of disturbance (an average of 11 percent per decade), followed by the Preferred Alternative, then Alternatives 4, 2, 3, and 5 (at 14, 15, 16, 17 percent, respectively). Alternative 5 would disturb the most acres, an average of 24 percent per decade, and would have the greatest affect on wetlands.

4.9.2 Introduction

Wetlands are defined as those "areas that are inundated or saturated with surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (Washington Administrative Code 222-16-010, Code of Federal Regulations 230.41a (1), U.S. Army Corps of Engineers Experimental Laboratory 1987). Wetlands are generally valued for the hydrologic, biogeochemical, and habitat functions that they perform. The primary environmental issue that relates to wetlands is the potential loss of wetland area or functions on forested trust lands due to forest management activities, including timber harvest and road construction.

4.9.3 Affected Environment

The policies and regulations that govern the management of wetlands on forested trust lands can be found in Appendix C.

4.9.3.1 Wetlands in Forested Trust Lands

Two sources of Geographic Information System data were used to identify acres of wetland in forested trust lands. The first source is FPWET, a DNR layer derived from National Wetlands Inventory data. National Wetlands Inventory, of the U.S. Fish and Wildlife Service, produces information on the characteristics, extent, and status of the nation's wetlands and deepwater habitats. The wetland maps are based on stereoscopic analysis of aerial photographs and are useful in identifying the general location and extent of wetlands. However, this wetland inventory is not based on site visits. National Wetlands Inventory is generally thought to underestimate the extent of forested wetlands.

The second data source is from the DNR Forest Resource Inventory System. The land types of the areas reviewed were identified photographically by DNR foresters and had various levels of field review. Because the review was based primarily on photographic interpretation, it could also underestimate the extent of forested and small wetlands. Both data sources were used to identify the extent of wetlands mapped in DNR forested trust lands. Where there was a conflict between the two layers regarding wetland type, the DNR Forest Resource Inventory System was used to determine the wetland status.

Approximately 1.5 percent of the land in forested trust lands is mapped as wetland. Of that, 44 percent is mapped as forested and 56 percent is mapped as non-forested. As discussed above, the actual acres of wetland may be higher because the identification was done primarily by using aerial photographs.

The six Habitat Conservation Plan Planning Units range between 0.7 and 2.5 percent wetland (Columbia – 0.7 percent, North Puget – 1.2 percent, Olympic Experimental State Forest – 1.4 percent, South Coast – 2.5 percent, South Puget – 1.7 percent, and Straits – 1.9 percent).

4.9.3.2 Wetland Functions

Wetlands are ecologically important because of functions related to water quality, floodwater retention, groundwater recharge, and habitat for many kinds of organisms:

- **Hydrologic functions** include discharge of water to downstream systems, low-flow augmentation and flood-peak attenuation, surface and subsurface water storage, water dissipation through transpiration, and sediment retention.

  Benefits: stabilization of streamflow, floodwater attenuation, improved water quality.
- **Biogeochemical functions** include organic carbon production and export, cycling of elements and compounds, and maintenance of conditions, including soils that support diverse plant communities.

  Benefits: food chain support, toxicant and nutrient recycling, natural waste treatment, substrate for habitat diversity.
- **Habitat functions** include maintenance of characteristic habitat structures, habitat interspersion and connectivity, and vegetative community composition.

  Benefits: essential habitat for amphibians and aquatic invertebrates, utilization for nesting and feeding by numerous bird and mammal species, food web support, human aesthetic enjoyment, connectivity for wildlife movement, and refugia during environmental fluctuations.

Timber harvest activities in or around wetlands may result in loss of wetland area and wetland function.

4.9.4 Environmental Effects

The Alternatives considered in this analysis do not propose to change any policies or procedures for managing forested wetlands, non-forested wetlands, or Wetland Management Zones. In all Alternatives, harvest and harvest-related activities would occur in forested wetlands outside Riparian Management Zones, and light access development and maintenance would be allowed in the Wetland Management Zones, when necessary. However, differences between Alternatives in policies and procedures for managing Riparian Management Zones would affect the forested wetlands within the Riparian Management Zone boundaries.

Potential effects to wetland functions are discussed below. Functions vary considerably among wetlands, and functions and impacts might not affect every wetland. Also, there are limited data available on wetland hydrology or the impacts of harvest on wetlands, specifically in the Pacific Northwest. Most of the studies available have been done in other parts of the country, and generalizations related to harvest activities in the Pacific Northwest should be stated with caution. Brief descriptions on the impacts to wetland functions are provided below; more detail is available in the Habitat Conservation Plan Environmental Impact Statement (DNR 1996).

4.9.4.1 Direct Effects

Forested Wetlands

Tree-harvesting, especially clearcutting, in wetland sites can alter wetland hydrology and raise the elevation of the water table. Timber harvest has also been found to increase the range of week-to-week water level fluctuations (Verry 1997).

Changes in hydrologic patterns of wetland sites can directly influence plant species and growth within the wetland site. Excessive water in the substrate stops root growth and microbial activity, and can lead to unfavorable biochemical activity (Verry 1997). As discussed in the Habitat Conservation Plan (HCP) Environmental Impact Statement (EIS) (DNR 1996), wetlands provide important habitat for plants and receive disproportionately high use by wildlife. Changes in vegetation and substrate can have positive or negative impacts on specific species.

The altered water table and associated streamflow relationship, over large areas, could increase localized runoff and flooding. These effects can be short term, and cease once a site becomes revegetated with emergent, shrub, or forest vegetation (Grigal and Brooks 1997). In some cases, an elevated water table resulting from timber harvest in a forested wetland could preclude the re-establishment of trees in the long term. Because there are little data on forested wetland hydrological response to timber harvest in the Pacific Northwest, this represents an unknown risk. An inability to regenerate trees would be considered a loss of function in a forested wetland. As discussed in the HCP EIS (DNR 1996), wetlands perform an important function in augmenting streamflow during low-flow periods and in moderating flows during storm events.

Water quality of wetland sites can be measurably affected by harvest activities, although effects can be transient depending on the activities (Shepard 1994). Harvest and associated activities (road-building and use) can deliver sediment to wetlands, diminish water quality, and lead to the filling of wetland sites. Nutrient pathways within wetlands can also be affected. Nutrients are removed directly from wetlands during harvest, and increases in export of nutrients can occur after harvesting.

The timing and method used to extract products from the forest can significantly influence effects on wetlands. Heavy equipment use in wetlands usually has concentrated impacts in specific areas that can alter soil properties locally. Additionally, soil rutting and compaction from timber-harvest activities can reduce infiltration, redirect flow, and alter pathways by which water moves through and from wetlands (Grigal and Brooks 1997).

Tree harvesting and associated activities can also affect wetland sites and adjacent or nearby land by potentially altering hydrology; changing nutrient pathways; delivering sediment (which can diminish water quality); changing species composition, growth, and structure; and reducing shading. These factors could result in some loss in wetland functions. While the hydrologic and biogeochemical functions begin to return as soon as tree revegetation occurs, habitat functions can require more time and forest regrowth to return.

The Forest Resource Plan policies and HCP strategies were developed to reduce the potential effects of harvest to forested wetland functions. Maintaining and perpetuating a windfirm stand with a minimum basal area of 120 square feet per acre should maintain at least 95 percent of the evapotranspiration and prevent large changes to hydrology (DNR 1996). Retaining these trees would also reduce the loss of habitat. Minimizing disturbance as directed in the Forest Resource Plan and HCP reduces potential impacts to water quality and other functions through reduction of sedimentation, retention of soil conditions, and cycling of nutrients. Thus, timber harvest impacts to forested wetlands are reduced while still allowing DNR to meet its other management objectives.

Another potential impact to forested wetlands is related to the wetland inventory done before a harvest. The Forest Practices Rules do not require an on-site survey to delineate all wetlands, but call for approximate determination of the wetland boundaries within the proposed harvest area. Forested wetlands and wetlands smaller than 0.25 acre are difficult to identify through aerial photographs, are not always accurately located on maps, and are sometimes difficult to distinguish on the ground, especially during the dry season. Therefore, a functioning wetland could be misidentified as non-wetland during the planning and/or harvest activities.

While efforts are made to prevent this type of error, a wetland could be harvested as non-wetland. In this case, the wetland would not receive the protection of minimized disturbance as directed in the Forest Practices Rules and HCP, and as discussed above. The wetlands would be expected to experience at least short-term loss in wetland area and/or functions. While the hydrologic and biogeochemical functions can return if there is tree revegetation, the habitat functions can require more time and forest regrowth to return.

Wetland Management Zones (Non-Forested Wetlands and their Associated Buffers)

There are no proposed changes in the policies and procedures for Wetland Management Zones. The non-forested wetlands and buffer could experience disturbance, localized clearing, and possibly loss of wetland acreage. The impacts to wetland functions would be similar to impacts discussed above for forested wetlands. If an activity results in the loss of wetland acreage, on-site and in-kind, equal-acreage mitigation would be required.

As with forested wetlands, approximate determination of the wetland boundaries within the proposed harvest area is required for non-forested wetlands. While there is still potential to misidentify non-forested wetlands during this process, it is less likely because they are easier to recognize. If non-forested wetlands are not correctly identified and buffered, they would not receive the protection of Wetland Management Zone designation and would experience the effects described under Forested Wetlands.

Road Construction

Construction of roads can have the greatest direct impact on wetlands because it permanently removes the area from the wetlands, thereby eliminating the associated biological functions and potential for future tree growth from the impacted area. Additionally, crossing wetlands with roads and without adequate provision for cross-drainage can lead to flooding on the upslope side and subtle drainage changes on the downslope side of crossings (Stoeckeler 1967; Boelter and Close 1974).

The Forest Practices Manual requires accurate delineation of wetland boundaries for the portions of any wetland where road construction could result in filling or draining more than 0.1 acre. This would ensure that all potential losses of wetland acreage are identified. Avoidance of wetlands during road planning is a primary method for preventing effects to wetlands. Where the wetlands cannot be avoided, the Forest Resource Plan requires no net loss of wetland acreage or function.

The Forest Resource Plan and Habitat Conservation Plan require on-site and in-kind, equal-acreage mitigation for wetland losses. By implementing this mitigation, there should be no significant net effect to the acreage or hydrologic and biochemical function of wetlands in the site. There can be a reduction in habitat for some species by building a road.

4.9.4.2 Indirect Effects

A less obvious impact to wetlands is the indirect impact of harvest in adjacent acreage. Harvest of adjacent acres may affect the water quality and hydrologic functions through increased sedimentation and changes in the local hydrology. Harvest also could have an effect on habitat functions.

The buffers required for forested trust lands and Olympic Experimental State Forest wetlands were selected to protect the wetlands from impacts of forestry activities. In the Forest Practices Rules Final Environmental Impact Statement (Washington Forest Practices Board 2001), several references were cited to show that, in general, a buffer width of 100 feet or greater has been found to provide protection from impacts to the water quality and hydrologic functions. Discussions in that document also noted that a larger buffer would be needed to fully protect fish and wildlife habitat functions. The buffers required by the Forest Resource Plan for forested trust lands are 100 feet or larger. Therefore, harvest effects to hydrologic and biogeochemical functions in non-forested wetlands should be prevented and effects to wetland habitat functions should be minor.

4.9.4.3 Comparison of Alternatives

The potential impacts described above are types of impacts that could result from harvest or harvest-related activities occurring in wetlands. None of the Alternatives proposes any changes in the policies and procedures for management of harvest or harvest activities in wetlands or wetlands buffers. The difference in environmental impacts to wetlands under the proposed Alternatives would be a function of the acreage to be harvested and the amount of related activities under each Alternative. Overall, Alternative 1 would result in the lowest level of disturbance (an average of 11 percent per decade), followed by the Preferred Alternative, then Alternatives 4, 2, 3, and 5 (at 14, 15, 16, 17 percent, respectively). Alternative 5 would disturb the most acres, an average of 24 percent per decade, and would have the greatest effect on wetlands.

The first comparison considered is the percentage of riparian and wetland area disturbed in each Alternative. Because wetlands and wetland buffers were not separated from the stream data in the model, the Riparian land class is used to compare Alternatives. The Riparian land class includes streams, stream buffers, wetlands, and wetland buffers. While this classification includes land that is not wetland, it allows for a relative comparison of activities in areas that are likely to contain wetlands.

The second comparison considered is harvest activity outside Riparian Areas that may affect wetlands. These two types of areas are Upland Areas with General Management Objectives and Upland Areas with Specific Management Objectives, such as protection of unstable areas and Habitat Conservation Plan-identified species habitat or visual corridors. A higher level of harvest activity in either of these non-riparian areas would be expected to have a higher potential to affect wetlands, through direct harvesting and related activities such as road-building. Table 4.9-1 summarizes the average harvest per decade by Alternative by land class.

Activities in the Riparian Land Class

For each Alternative, the amount and type of harvest proposed for riparian areas is different. The impacts to the Riparian land class for each Alternative are discussed in detail in Riparian Areas (Section 4.3). Table 4.9-1 provides a summary of the average harvest by decade in the riparian and wetland areas for each Alternative.

Table 4.9-1. Average Percent of Acres in each Land Class Harvested per Decade

Alternative	Percent of Area of Land Class Harvested per Decade			
	Riparian and Wetland Areas (percent)	Uplands with Specific Objectives[1/] (percent)	Uplands with General Objectives (percent)	Total All Classes (percent)
1	2	11	20	**11**
2	4	22	21	**16**
3	5	21	26	**17**
4	5	16	25	**15**
5	7	37	27	**24**
PA	8	17	16	**14**

DNR source: Model output data – timber flow levels.
1/ Includes uplands with protection for unstable areas and Habitat Conservation Plan-identified species habitat, and visual corridors.
PA = Preferred Alternative

In riparian areas, Alternative 1 has the lowest level of activities, with an average of about 2 percent of acres disturbed per decade. Therefore, Alternative 1 would have the lowest potential to affect wetlands. This is followed by Alternative 2 with 4 percent per decade, Alternatives 3 and 4 with 5 percent, and Alternative 5 with 7 percent. The Preferred Alternative would have the highest level of harvest-related activities in Riparian Areas, with an average of 8 percent of acres disturbed per decade, which is the result of thinning to develop structurally diverse stands. Therefore, the Preferred Alternative would have the highest potential to affect wetlands in Riparian Areas, followed closely by Alternative 5.

Activities in the Upland Land Classes

In Upland Areas with Special Management Objectives, Alternative 1 has the lowest level of activities, with an average of about 11 percent of acres disturbed per decade. Therefore, Alternative 1 would have the lowest potential to affect wetlands in this land class. This is followed by Alternative 4 with 16 percent per decade and the Preferred Alternative with 17 percent per decade. Alternatives 2 and 3 would disturb 22 and 21 percent, respectively. Alternative 5 would have the highest level of harvest-related activities, with an average of 37 percent of acres disturbed per decade. Therefore, Alternatives 5 would have the highest potential to affect wetlands in the Upland Areas with Special Management Objectives and Alternative 1 the least.

In the Upland Areas with General Management Objectives, the Preferred Alternative (16 percent disturbance per decade) would have the lowest potential to affect wetlands. This is followed by Alternatives 1, 2, 4, 3, and 5, at about 20, 21, 25, 26, and 27 percent disturbance per decade, respectively. Alternative 5 would have the highest level of activities; therefore, Alternatives 5 would have the highest potential to affect wetlands in the Upland Areas with General Management Objectives, but the difference between Alternatives 1 through 5 is not as large as is the case in Uplands with Specific Objectives.

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4.10 FISH

4.10.1 Summary of Effects

This section analyzes the environmental effects on fish. The analysis examines the current policy and procedures and uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

In general, the effects would be expected to follow those described in Section 4.3, Riparian Areas. Over the long term, all Alternatives would be expected to result in improved riparian and aquatic conditions for fish because of increased riparian function associated with continued growth or restoration of riparian stands. Larger and taller riparian tree stands with multiple canopy layers are expected to increase shade levels, functional in-stream large woody debris, leaf and needle litter, and improvements to coarse and fine sediment input and hydrologic regimes. In part, this would result by recovery from current degraded conditions in many areas caused by practices prior to the Habitat Conservation Plan rather than enhancement of natural conditions.

Relative to Alternative 1 and other Alternatives, the Preferred Alternative is expected to have more beneficial effects by increasing the rate at which riparian stands transition to structurally diverse, fully functioning stands. However, the Preferred Alternative also includes more intensive management of riparian areas for habitat enhancement. Under the Preferred Alternative, management activities would include a moderate level of infrequent, but heavy thinning activities designed to promote structural diversity in competitive exclusion stands that currently dominate in riparian areas. The current and proposed policies and procedures are designed to avoid, minimize, and mitigate for forest management practices on forested trust lands that have the potential to adversely effect the aquatic habitat features described below. On a relative basis, the slightly higher activity levels proposed under Alternative 5 and the Preferred Alternative suggest a slightly higher risk of adverse effects from forest management activities if mitigation measures are followed. Regardless of Alternative, the potential for adverse effects appear to be within levels anticipated under the Habitat Conservation Plan.

4.10.2 Introduction

Fish species are important natural resources that have ecological, economic, and cultural significance in the state of Washington. Pacific salmon and trout are good indicators of a properly functioning aquatic ecosystem, because they require cool, clean water; complex channel structures and substrates (beds under water bodies); and low levels of fine sediment (Bjornn and Reiser 1991). In addition, Pacific salmon and trout populations have provided for viable commercial and sport fishing industries. During the scoping process for sustainable forestry and associated harvest level, concerns were expressed about how the Alternatives would affect water quality, riparian areas, and aquatic habitat, including aquatic species. There were concerns about the potential effects of road maintenance, possible new road-building, and road abandonment.

For the purpose of this project, DNR forested trust lands are estimated to include approximately 13,950 miles of streams. About one-third (4,590 miles) of these streams are fish-bearing Type 1 to 3 streams[1]. The remaining streams do not support fish, but can influence downstream conditions through the transport of water, nutrients, leaf and needle litter, sediment, and woody debris. Numerous factors affect fish population numbers, which can be highly dynamic. Many of these factors are unrelated to forest practices on forested trust lands. Consequently, this analysis focuses on fish habitat rather than population numbers.

The effects analysis presented in Section 4.10.3 relies heavily on analyses presented earlier in this document including:

- Riparian Areas (Section 4.3)
- Geomorphology, Soils, and Sediment (Section 4.6)
- Hydrology (Section 4.7)
- Water Quality (Section 4.8)

The fish effects analysis synthesizes the pertinent components of the above analyses. These sections evaluate the components of the aquatic environment described below in Section 4.10.3 and the major issues developed during the scoping process.

4.10.3 Affected Environment

4.10.3.1 Priority Species

Fish species selected as the focus of this analysis include chinook, sockeye (kokanee), coho, and chum salmon; steelhead (rainbow); coastal cutthroat; and bull and Dolly Varden trout. These species were selected because, with the exception of Dolly Varden trout, they are listed as threatened under the federal Endangered Species Act or are a candidate species (coho salmon). All of the species mentioned have commercial or sport harvest value and are known to be sensitive to forest management activities. See page 3-121 of the Forest Practices Rules Final Environmental Impact Statement (Washington Forest Practices Board 2001) for additional details regarding these species.

The status of listed salmon species in Washington is currently undergoing re-assessment under the Endangered Species Act. In September 2001, the U.S. District Court in Eugene, Oregon, determined that the National Oceanic and Atmospheric Administration Fisheries Service could not split Oregon coast coho salmon into two components, hatchery and wild, and only list one component (wild fish) under the Endangered Species Act. While this decision did not specifically affect any listed salmon other than Oregon coast coho, the decision did prompt the Fisheries Service to re-assess the listing status and critical habitat designations for salmon species throughout much of the Pacific coast.

[1] The current DNR Geographic Information System layer for streams is believed to underestimate the amount of Type 3 streams. Consequently, for the purposes of the sustainable harvest calculations, stream types in the DNR Geographic Information System stream layer were modified by upgrading Type 9 and Type 5 streams to Type 4, and Type 4 streams to Type 3 (see Appendix B).

In addition to these re-assessments, the Fisheries Service is also considering how to treat hatchery populations identified in the Endangered Species Act listing determinations. The draft results of these determinations are expected to be published in mid-2004. Within the proposed rule (69 FR 33102, June 14, 2004), the Fisheries Service indicated that most anadromous salmon species listed in the Endangered Species Act would likely remain listed with their current status. The proposed rule would affect the status of the lower Columbia River coho evolutionarily significant unit located in southwestern Washington and portions of northern Oregon by downgrading from a candidate to threatened species status. The status of all other salmonid species that might be affected by activities on forested trust lands would not change under the proposed rule.

Regardless of potential changes in the Endangered Species Act status of these species, it is unlikely that the status of freshwater habitat conditions considered degraded in many westside watersheds has improved substantially since the Fisheries Service Endangered Species Act Status Reviews (see NOAA Fisheries [2003a] for a comprehensive list). The Habitat Conservation Plan (DNR 1997) has been in place only since 1997. Consequently, monitoring has not been conducted sufficiently long enough to demonstrate significant improvements in habitat conditions (DNR 2002b). Improvements in ocean conditions during the last few years have resulted in increased adult returns of Pacific Northwest salmon. However, these increases may also be influenced by other conservation efforts in the region (NOAA Fisheries 2003b).

A basic understanding of the life history and habitat requirements of Pacific salmon and trout is important for recognizing the type and level of effects that may result from a land-use activity such as timber harvest. The following represents a brief overview of salmon and trout life history. Additional details of species-specific traits can be found on pages 3-120 through 3-129 in the Forest Practices Rules Final Environmental Impact Statement (Washington Forest Practices Board 2001).

The life cycle of Pacific salmon and trout can be divided into seven distinct phases or lifestages: upstream migration, spawning, egg incubation, fry emergence, juvenile rearing, smolt outmigration, and marine rearing. One commonly recognized variation in life history traits for Pacific salmon and steelhead is the duration of freshwater rearing and the type of habitat that is used. It is the freshwater rearing period that is most vulnerable to land-use practices, including forest practices. Consequently, those species of fish with the longer stream-rearing periods are more likely to be adversely affected by forest practices.

Spring chinook salmon, coho salmon, and steelhead juveniles typically spend 1 or 2 years rearing in streams prior to migrating to the sea. Similarly, sockeye salmon usually spend a year rearing in a lake prior to their migration. In contrast, fall chinook and chum salmon migrate to the ocean as fry (small sub-yearling fish). Chum salmon usually complete their migration shortly after emergence (Wydoski and Whitney 1979), while fall chinook may have a prolonged migration period that occurs throughout the summer (Dawley et al. 1986). Five of the species (kokanee, rainbow, cutthroat, bull, and Dolly Varden trout) have life history forms that do not have a marine phase. They live their entire lives in freshwater.

During the period of freshwater rearing, Pacific salmon and trout have life-stage and species-specific habitat requirements for spawning and rearing. Important aspects to spawning habitat include substrate size (size of pebbles, rocks, and composition of the bottom of the stream or water body), water depth, and water velocity (Bjornn and Reiser 1991). In general, the larger species utilize larger substrates and deeper and faster water. Tail-outs to pools (the downstream end where the pool changes to a riffle or run) that meet criteria for these features are generally considered optimal spawning areas because stream structure maximizes the passage of oxygenated water through redds (nests dug by the fish in the substrate). However, runs and riffles are also used during spawning.

Following emergence from the redd, salmon and trout fry typically use shallow and slow-moving areas of a stream. Optimal depths and velocities increase as the fish grow, but preferred areas are usually associated with some form of cover, usually pools with large woody debris or boulders. Differences among the species are apparent in the degree of flexibility for utilizing riffles, runs, and other habitat features. Drifting insect larvae and benthic macroinvertebrates account for the majority of food items eaten by juvenile salmon and trout within streams.

In contrast to other salmon species, sockeye fry migrate to a lake shortly after emergence where shallow nearshore areas are preferred habitat. As sockeye fry grow, they begin to move offshore and have a characteristic diurnal vertical migration timed for utilization of zooplankton food sources.

4.10.3.2 Aquatic Ecosystem (Habitat Components)

Key physical components of the aquatic ecosystem include channel morphology or structure (floodplains, streambanks, channels), water quality, and water quantity. Habitat complexity is created and maintained by rocks, sediment, large woody debris, and favorable water quantity and quality. Upland and riparian areas influence aquatic ecosystems by supplying sediment, woody debris, and water. Disturbances such as landslides and floods are important mechanisms for delivery of wood, rocks, and pebbles that contribute to the streambed.

Natural channels are complex and contain a mixture of habitats differing in depth, velocity, and cover (Bisson et al. 1987). They are formed during storm events that have associated water flows that mobilize sediment in the channel bed (Murphy 1995). The hydrology, or the way water moves through the watershed, combined with its geology, hillslope characteristics, and riparian vegetation determine the nature of stream channel morphology (Sullivan et al. 1987, Beschta et al. 1995). Therefore, activities in these areas would be expected to affect the shape and form of the stream channel. For example, substantial increases in volume and frequency of peak flows can cause streambed scour and bank erosion. A large sediment supply may cause aggradation (i.e., filling and raising the streambed level by sediment deposition) and widening of the stream channel, pool filling, and a reduction in gravel quality (Madej 1982). Upslope activities (e.g., timber harvest, land clearing, and road development) can change channel morphology by altering the amount of sediment or water contributed to the streams. This, in turn, can disrupt the balance of sediment input and downstream movement in a stream reach (Sullivan et al. 1987).

Streams that lack a balance between pools and riffles (i.e., too few pools) are often less productive for salmon and trout than streams that have more complex structure. Pools are used as holding and resting areas for adult fish prior to spawning, deep water cover for protection, and cool water refugia during low-flow summer months. Riffles are important for re-oxygenation of water and habitat for food organisms such as aquatic macroinvertebrates (Gregory and Bisson 1997). Intensive timber harvest next to the water body has been reported to decrease pool depth, surface area, and the general diversity of pool character (Ralph et al. 1994). Possible mechanisms include decreased occurrence of large woody debris, which can help to form and stabilize pools, and filling of remaining pools with bed material.

The following describes components to the aquatic ecosystem that are influenced by forest practices. These include coarse sediment, fine sediment, hydrology, large woody debris, leaf/needle litter recruitment, floodplains and off-channel features, water temperature, forest chemicals (contaminants), and fish passage.

Coarse Sediment. Bedload material is necessary to provide substrate for cover and spawning habitat for fish. However, increased levels of coarse sediment bedload above background levels can lead to streambank instability, pool filling, and changes in the water transport capacity of the channel (Spence et al. 1996). Higher flows are required to mobilize larger sediment sizes. Consequently, the recovery period for streams with severe coarse sediment aggradation could range from decades to 100 years or more. The major factors influencing the excessive delivery of sediment to a stream include the intensity and location of streambank erosion, mass-wasting events, and road and culvert failures.

Fine Sediment. Fine sediment can degrade the quality of fish habitat by increasing water turbidity that restricts sunlight penetration. Sediment can also fill the pores between the gravel and prevent the flow of oxygen-rich water to fish eggs that may be deposited there (Bjornn and Reiser 1991). Fine sediments and larger particles such as sand-sized fractions can also smother fish eggs and developing young in the gravel, clog pores or breathing surfaces of aquatic insects, physically smother them, or decrease available habitat (Spence et al. 1996; Washington Forest Practices Board 2001).

Biological effects of increased turbidity may include a decrease in primary productivity of algae and periphyton due to the decrease in light penetration. Declines in primary productivity can adversely affect the productivity of higher trophic levels such as macroinvertebrates and fish (Gregory et al. 1987). Turbidity can also interfere with feeding behavior or cause gill damage in fish (Hicks et al. 1991), but may provide some benefits. For example, it can provide cover from predators (Gregory and Levings 1998).

Important factors related to forest management activities that can influence the excessive delivery of fine sediment to a stream include the presence of wetlands (see Section 4.9) and adequate streamside vegetation to filter fine sediment from hillslopes and road surface erosion (see Section 4.6).

Hydrology. The amount of water provided to aquatic ecosystems at critical times is important for sustaining fish and other aquatic species. Many fish species and populations have become adapted to natural flow cycles for feeding, spawning, migration, and survival needs. The timing, magnitude, and duration of peak and low flows must be sufficient to create and maintain riparian and aquatic habitat. Wetland areas are also an important component to hydrology by storing water and later releasing it directly to streams or through groundwater. In general, low- or base-level streamflows that occur during the late summer often limit habitat for rearing juvenile salmon and trout. High winter flows and floods that scour the streambed can be detrimental to eggs or young fish that may be incubating in the stream gravels. Rain-on-snow events are a common reason for flooding and streambed scour on the west of the Cascade Mountains and can be influenced by management activities such as timber harvest and roads (see Section 4.7).

Large Woody Debris. Large woody debris includes trees and tree pieces greater than 4 inches in diameter and 6 feet long (Keller and Swanson 1979; Bilby and Ward 1989). While large woody debris is considered one of the most important components of high-quality fish habitat (Marcus et al. 1990), the value of a particular piece of large woody debris in providing aquatic habitat depends on the stream size, tree species, and numerous other factors (see Section 4.3). Large woody debris provides food and building materials for many aquatic life forms and is important for stream nutrient cycling, macroinvertebrate productivity, and cover for juvenile and adult fish (Marcus et al. 1990). Large woody debris is also the primary channel-forming element in some channel types and affects many aspects of channel structure including stream roughness, sediment storage, water retention, energy dissipation, and fish habitat (Lisle 1986; Swanson et al. 1987; Marcus et al. 1990; Martin and Robinson 1998). Pools formed by stable accumulations of large woody debris provide important habitat for rearing salmon and trout, particularly in winter (Heifetz et al. 1986; Murphy et al. 1986).

Field studies in streams flowing through old Douglas-fir forests in coastal Oregon and Washington have shown that the number of woody debris pieces varies by channel width and size of debris under undisturbed conditions (Bilby and Ward 1989; Washington Forest Practices Board 1995). Coniferous wood (e.g., Douglas-fir or cedar) is more resistant to decay than deciduous wood (e.g., alder). Therefore, coniferous wood has a greater longevity in a stream (Cummins 1994 as cited in Spence et al. 1996).

In general, information on large woody debris must be viewed from the perspective of past timber harvest activity in an area, historical floods that have removed or redistributed large woody debris, and the activities that were performed to actively remove large woody debris (Maser and Sedell 1994). Long-term potential large woody debris recruitment from existing mature or old forest riparian zones would be anticipated to be higher than younger or recently clearcut areas (see Section 4.3.3.1, Riparian Functions).

Leaf and Needle Recruitment. The abundance and diversity of macroinvertebrate food sources to salmonids is dependent upon the primary algae and detrital food sources. Forest harvest activities affect the food chain by changing the relative macroinvertebrate production between herbivores and detritivores (Gregory et al. 1987). Many bacterial and macroinvertebrate species rely directly on detrital material from disintegrating leaf and needle litter, branches, and stems from the surrounding riparian zone vegetation. Some estimates indicate that leaf and needle recruitment may provide up to 60 percent of the total energy input to stream communities (Richardson 1992). In streams containing spawning habitat for Pacific salmon, significant influxes of nutrients from the marine environment occur during the decomposition of fish carcasses (Bilby et al. 1996).

Other macroinvertebrate species rely on aquatic algae that primarily use dissolved chemical nutrients (which are partially derived from decomposed litter, carcasses, and other sources), require solar radiation, and are affected by the amount of shade present in a stream reach. Although shade is important for maintaining cool water temperatures, more shade or complete shading does not always maximize aquatic productivity. The availability of in-stream algae can be a limiting factor in some streams. Algae and other sources of vegetable matter are at the lowest level of the food chain and important to higher trophic level production such as fish. High levels of shade can result in low levels of algae production even if adequate nutrient sources are present (Gregory et al. 1987). Under unmanaged conditions, forested lands generally have low light and low primary productivity in low-order streams with high canopy cover. In contrast, primary productivity in wide, high order streams is generally unaffected by riparian management because light penetration occurs even under mature riparian conditions (Gregory et al. 1987).

Floodplains and Off-Channel Habitat. Floodplains and off-channel areas are important components of aquatic habitat that provide side channels, wall-base channels, backwater alcoves, ponds, and wetlands. They also provide important habitat seasonally to particular life stages of fish as well as input of organic matter and large woody debris. Floodplains and off-channel habitat are protected under the Habitat Conservation Plan by establishing Riparian Management Zones that begin at the outer edge of the 100-year floodplain.

Water Quality (Temperature and Dissolved Oxygen). Water temperature plays an integral role in the biological productivity of streams and is an important factor influencing dissolved oxygen levels. Water temperature and dissolved oxygen levels can affect all aspects of salmon and trout life in fresh water including:

- incubation and egg survival in-stream gravel;
- emergence, feeding, and growth of fry and juvenile fish;
- outmigration of young fish;
- adult migration, holding and resting; and
- pre-spawning and spawning activities.

In coldwater species such as salmon and trout, water temperatures in the range of 70°F (about 21°C) or greater can cause death within hours or days (Oregon Department of Environmental Quality 1995). In general, water temperatures of 53° to 58°F (11.8° to 14.6°C) have been found to provide a properly functioning condition for juvenile salmon and trout. However, bull trout require much lower temperatures during spawning (39° to 50°F [4 to 10°C]) and egg incubation (34° to 43°F [1 to 6°C]) (Oregon Department of Environmental Quality 1995).

Increases in water temperature in forest streams can often be traced to a reduction in shade-producing riparian vegetation along fish-bearing and tributary streams that supply water to other fish-bearing streams (see Riparian Areas, Section 4.3). Long-term sublethal temperature effects can be detrimental to the overall health of a population, as can short-term acute effects of warm water temperatures on coldwater aquatic species. Heat stress may accumulate such that increased exposure for juvenile fish results in an environment in which growth is reduced or the inability to meet increased metabolic (energy) demands increases their susceptibility to disease (Oregon Department of Environmental Quality 1995).

Forest Chemicals. Water quality contaminants (e.g., petroleum products, chemicals, fertilizers, herbicides, sewage, and heavy metals) can severely impair aquatic ecosystems either by sublethal (e.g., reduced growth) or lethal effects (e.g., fish kills). The water quality contaminants considered herein are pesticides and herbicides used to prevent tree diseases and deter pest plant species that compete with trees for nutrients, space, and light.

Fish Passage. Upstream migration of adult salmon, steelhead, and trout to spawning areas or redistribution of rearing fish to potential habitat in upstream areas can be impeded or blocked by a number of different mechanisms. These mechanisms can include water temperature, dissolved oxygen, turbidity, and natural and man-made physical barriers (Reiser and Bjornn 1979).

Stream crossings by forest roads are the most common passage barrier influenced by forest practices. Barriers such as culverts used at stream crossings can prevent passage due to high water velocities, restricted depths, excessive elevation of the culvert (too high above stream level) for successful entry, size and length, and other factors. Shallow water depths from conditions such as low flow can also impede or prevent passage by causing riffles between pools to become completely dry or lack sufficient depth for passage. Similarly, some debris jams can prevent or delay upstream passage (Reiser and Bjornn 1979).

4.10.4 Environmental Effects

The changes proposed to policies and procedures under the Alternatives are described in Chapter 2. Other policies and procedures that affect fish and riparian conditions are described in Appendix C. Policy or procedural changes would directly or indirectly affect fish or fish habitat by modifying the intensity and frequency of harvest activities in areas (primarily riparian areas) that are available to harvest. Potential changes include those related to trust ownership groups, harvest flow, value- versus volume-based control of timber harvest, minimum forest stand regeneration age, and northern spotted owl conservation management strategies.

4.10.4.1 Alternatives Analysis by Habitat Component

Coarse Sediment. Excessive coarse sediment entering streams is commonly the result of forest management activities on unstable slopes or failures at road-stream crossings. All of the Alternatives would avoid activities on unstable slopes and are expected to have similar amounts of new road construction using modern construction standards. Consequently, no significant difference is expected among the Alternatives relative to coarse sediment entering streams. Please see Geomorphology, Soils, and Sediment (Section 4.6) for additional details.

Fine Sediment. Although restoration activities are allowable throughout the riparian buffer under the Habitat Conservation Plan (Pages IV.59-60), none of the Alternatives proposes activities within the 25-foot no-harvest buffer along Types 1 through 4 streams, except for yarding corridors and roads. Consequently, none of the Alternatives are likely to have a significant adverse effect on streambank stability or sediment filtering capacity from surface erosion as long as appropriate mitigation measures are also implemented, such as Road Maintenance and Abandonment Plans and full suspension yarding within the no-harvest zone. Please see Geomorphology, Soils, and Sediment (Section 4.6) and Riparian Areas (Section 4.3) for additional details.

Hydrology. The effects of the Alternatives on hydrology were analyzed based upon the potential changes in the amount of hydrologically mature forest in the rain-on-snow zone and amount of harvest in the riparian areas. Constraints to harvest in the rain-on-snow zone are the same under all Alternatives. Consequently, none of the Alternatives allows harvest of hydrologically mature forest in rain-on-snow zones below critical levels (66 percent of the zone). Even at the higher harvest levels in the riparian zone expected under Alternative 5 and the Preferred Alternative, detectable adverse effects to the local peak flows of the waterbody are unlikely.

Large Woody Debris. The potential of adding more large woody debris is expected to improve under all of the Alternatives. Over the short term, all of the Alternatives are expected to produce about the same amount of riparian area included in stand development stages with large and very large trees, i.e., trees more than 20 inches in diameter (about 61 to 62 percent of the Riparian land class).

Over the long term, Alternatives 1 and 4 are expected to result in the highest amount of riparian area (about 90 percent of the Riparian land class) in stand development stages with large or very large trees, followed in descending order by Alternatives 2, 3, and 5 (about 82 to 83 percent of the Riparian land class), and the Preferred Alternative (about 78 percent). Although the Preferred Alternative is predicted to have the lowest area of stand development stages with large and very large trees among the Alternatives, it is also predicted to result in the highest amount (about 13 percent) of Riparian land class area in niche diversification and fully functioning stand development stages, while Alternative 5 is predicted to have the lowest amount (about 4 percent).

The major feature that distinguishes these two stand development stages from other stages with large and very large trees is the presence of multiple canopy layers and higher levels of decadence such as snags, down coarse woody debris, and epiphytes. Alternatives 1 and

4, which are expected to have the highest area of stand development stages with large and very large trees, are predicted to have about 7 percent of Riparian land class area in niche diversification and fully functioning stand development stages. Consequently, over the long term, the Preferred Alternative is expected to produce higher riparian function on more of the Riparian land class relative to Alternative 1, but with the trade-off of having less area of stand development stages with large and very large trees in the Riparian land class during the Habitat Conservation Plan period.

Based upon the model outputs, the potential for adverse effects to fish resources from all Alternatives for the first decade is expected to be minimal in all HCP Planning Units because harvest activity levels are relatively low, at less than 8 percent of the Riparian land class, and average about 7 percent or less for all decades and HCP Planning Units. The differences would generally be minor except under the Preferred Alternative and Alternative 5. Under these Alternatives, large woody debris recruitment potential in some HCP Planning Units could be slightly lower during some decades because of the relatively high level of activity, to as much as about 20 percent of the Riparian land class during a decade, primarily from heavy thinning activities. Under Alternative 5, riparian timber harvest in the Olympic Experimental State Forest is expected to result in disturbance levels as high as approximately 15 percent in an individual decade. Unlike Alternative 5, the Preferred Alternative would likely produce more acres of niche diversification and fully functioning riparian stands over the long term and place more stands on a trajectory towards full function because of more intensive active silvicultural management designed to increase the structural complexity of riparian stands. In addition, the biodiversity pathway treatments proposed under the Preferred Alternative include activities to create downed wood (i.e., fall and leave in place large trees), which can also act as in-stream large woody debris if targeted for the stream corridor. However, the Preferred Alternative would also likely result in fewer riparian acres of large and very large trees within the Habitat Conservation Plan planning period. Those areas with large and very large trees that do not receive the treatments proposed under the Preferred Alternative may require substantially longer periods (over 100 years) to achieve full riparian function (Carey et al. 1996).

Additional details concerning large woody debris recruitment and the likely effects of the Alternatives can be found in Section 4.3 (Riparian Areas).

Floodplains and Off-Channel Habitat. Protection of floodplains and off-channel habitat is not expected to differ among the proposed Alternatives. Harvest activities prior to implementation of the Habitat Conservation Plan sometimes resulted in the harvest of trees right to the stream edge and did not consider protection to floodplains and off-channel habitat. Consequently, these areas are expected to improve under all Alternatives, while riparian vegetation in these areas grows. Active management under Alternatives 2, 3, 5, and the Preferred Alternative could result in thinning or hardwood conversion activities, but these activities are not expected in floodplains, off-channel habitat, or the 25-foot no-harvest zone required in the five Westside HCP Planning Units.

Water Quality. Increases in water temperatures along forest streams can often be traced to a reduction in shade-producing riparian vegetation (see Riparian Areas, Section 4.3). Water temperatures in forested trust lands would likely be maintained or improved over the long term under all Alternatives. The presence of very large trees is important for maintaining stream shade and cool water temperatures, particularly for larger streams. Over the short term, all Alternatives are expected to result in about the same amount of area in stand development stages with large and very large trees. Over the long term, Alternatives 1 and 4 are expected to have the highest amount of riparian area in stand development stages with large and very large trees, followed in descending order by Alternatives 2, 3, and 5. The Preferred Alternative is expected to have the lowest amount of the Riparian land class in stands dominated by large and very large trees, but is also expected to have the largest area in structurally complex stand developmental stages.

Improvements in stream shade anticipated under Alternative 5 and the Preferred Alternative may be slightly less than under Alternatives 1 through 4 over the short term because of the harvest of riparian trees and potentially greater numbers of yarding corridors. Harvest activities in upland land classes is expected to average about 18 percent per decade under Alternative 5 compared to about 9 to 13 percent for the other Alternatives. Consequently, the need for cross-stream yarding and yarding corridors may be higher for Alternative 5, but not the Preferred Alternative, which is near the lower end of the range of upland harvest levels. However, Alternative 5 and the Preferred Alternative could result in slightly lower levels of stream shading in some HCP Planning Units during some decades, because of the higher level of disturbance, as much as approximately 15 percent of the Riparian land class during a given decade under Alternative 5 and as much as 20 percent under the Preferred Alternative. The short-term reductions in shade that might occur form tree removals in the riparian zone under the Preferred Alternative are primarily designed for long-term enhancement of riparian stands and are expected to result in relatively high levels of shade over the long term.

Additional details concerning water quality and the likely effects of the Alternatives can be found in Water Quality (Section 4.8) and Riparian Areas (Section 4.3).

Forest Chemicals. Little or no use of forest chemicals such as fertilizers and herbicides is expected under Alternatives 1 through 4. Alternative 5 and the Preferred Alternative propose higher use in terms of frequency and amounts. However, mitigation measures implemented by DNR, such as manual application in riparian zones, exist to reduce the likelihood of forest chemicals entering streams. Consequently, none of the Alternatives is expected to result in significant adverse affects to water quality and the associated fish resource from forest chemicals. Please see Water Quality (Section 4.8) for additional details.

Leaf and Needle Recruitment. Relative to current conditions, leaf and needle litter recruitment to streams would be expected to increase in the long term under all of the Alternatives due to growth of trees in the riparian zone. However, relative to Alternative 1, the improvement in leaf and needle litter production may be slightly less under Alternatives with higher activity levels because of the harvest of some riparian trees and potentially greater numbers of yarding corridors. The amounts of these activities are expected to be generally minor, although the risk of adverse effects may be slightly higher under Alternative 5 and the Preferred Alternative due to slightly higher riparian activity levels. Over the long term, riparian areas treated under the biological pathways approach of the Preferred Alternative are expected to more rapidly achieve fully functioning stand characteristics, including higher levels of leaf and needle recruitment in comparison to stands that remain in competitive exclusion stages for long periods.

Fish Passage. The amount of new road construction needed for stand access is expected to be similar under all Alternatives. New roads and any stream crossings needed would be built using current standards that require adequate fish passage. Replacement of sub-standard stream crossings that are considered passage problems will occur as part of DNR's road maintenance and abandonment program. Fish passage at man-made structures would be expected to improve over time under all of the Alternatives.

4.11 PUBLIC UTILITIES AND SERVICES

4.11.1 Summary of Effects

This analysis considers the potential effects of the Alternatives on harvest volumes. Volume directly affects revenue to the beneficiaries and some beneficiaries partially fund public utilities and services with timber revenue. This section also considers the potential effects of the proposed Alternatives on transportation infrastructure. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

The Alternatives provide a wide array of direct economic benefits to the beneficiaries. In other words, the relationship between the Alternatives is not consistent across all beneficiaries. Projected annual average harvest levels are, for example, highest for agricultural school grant lands under the Preferred Alternative, but highest for university grant lands under Alternative 5. This variation is also evident for western Washington forested state trust lands when projected harvest levels are viewed by county. Projected forested state trust lands harvest levels are, for example, highest under Alternative 5 in Wahkiakum County, but highest under Alternative 3 in Skamania County. These modeling outputs do not provide precise harvest schedules, but they can represent a likely distribution of harvest levels over time at the county level. While they provide an indication of the possible distribution of harvest by county, it is difficult to predict what effect this variation would have on the built environment.

Potential effects on transportation infrastructure would vary by Alternative, with larger projected harvest volumes resulting in increased logging truck traffic. Alternatives with larger projected harvest volumes would, however, also result in more revenue available for maintenance and improvements to public utilities and services. Potential transportation impacts would occur within the context of total forest management activity within the state of Washington and surrounding regions. Current DNR harvests represent about 13 percent of total western Washington harvest. Logging companies harvesting timber from forested trust lands must meet Washington State Department of Transportation weight requirements and pay taxes that support road improvements. DNR regularly meets with local government officials and engineers to discuss the effects of logging-related traffic (DNR 1992b). These measures would help mitigate potential impacts associated with increased road traffic. As a result, none of the Alternatives is expected to result in any probable significant adverse environmental impacts on transportation infrastructure.

4.11.2 Introduction

This section provides an overview of the potential effects of the proposed Alternatives on public utilities and services. Public utilities and services were not directly raised as issues during scoping, but some issues were raised with respect to revenue generation from management of forested trust lands. These include concerns with predictable and reliable flows of revenue to trust beneficiaries.

The potential effects of the Alternatives on harvest volumes, and therefore trust revenues, are considered here in general terms because these revenues are mainly used by beneficiaries to fund public utilities and services, particularly schools. The potential effects of the proposed Alternatives on transportation infrastructure are also discussed in this section.

4.11.3 Affected Environment

4.11.3.1 Forested State Trust Lands and Trust Beneficiaries

There are three types of forested state trust land: federal grant, state forest (formerly known as Forest Board), and community college forest reserve. These three types of lands are discussed in the following sections.

Federal Grant Lands

The Omnibus Enabling Act of 1889 set aside 2 square miles out of every 36 (2 sections in each township) in the state to provide financial support for the common schools. The Act also granted additional sections of land to other state institutions. These lands, known as “federal grant lands,” consist of eight specific trusts, including:

- **Agricultural school** lands, which support Washington State University in Pullman.
- **Capitol building** lands, which support the construction of state office buildings on the capitol campus in Olympia.
- **Charitable, educational, penal, and reformatory institutions** lands, which support these public institutions.
- **Common school** lands, which support the construction of public schools.
- **Normal school** lands, originally designated to support the state teachers colleges, which have become the regional universities: Western Washington University, Central Washington University, Eastern Washington University, and The Evergreen State College.
- **Scientific school** lands, which support Washington State University.
- **University original** lands, which support the University of Washington. Only a small amount of that acreage remains.
- **University transfer** lands, which were originally part of the charitable, educational, penal, and reformatory institutions trust but were designated by the state legislature to provide additional support to the University of Washington.

Approximately 844,000 of the 2.2 million acres of federal grant trust lands in the state of Washington in 2001 were located in westside counties (Table 4.11-1). Approximately 92 percent (773,000 acres) of the federal grant trust lands in westside counties were forested (Table 4.11-1). These acreages are shown by trust in Table 4.11-1. The common school lands accounted for about 508,000, or 66 percent, of forested federal grant trust acres in western Washington.

Table 4.11-1. Trust Lands Managed by DNR, by Trust Beneficiary

	Total Acres[1/]	Total Forested Acres[1/]	Westside Acres[2/3/]	Westside Forested Acres[4/]
Federal Grant Trust Lands				
Agricultural School Grant (Washington State University)	70,733	56,783	27,579	26,210
Capitol Building Grant	108,281	100,290	91,715	85,460
Charitable, Educational, Penal, and Reformatory Institutions Grant	70,278	40,141	29,289	26,810
Common School, Indemnity, and Escheat Grants	1,746,020	1,103,452	560,377	508,307
Normal School Grant (Eastern Washington University, Central Washington University, Western Washington University, and The Evergreen State College)	64,304	57,005	34,757	32,549
Scientific School Grant (Washington State University)	80,455	68,549	56,268	52,995
University Grants (University of Washington) Original and Transferred	86,806	56,954	43,723	41,130
Federal Grant Trust Land Total	**2,226,877**	**1,483,174**	**843,708**	**773,461**
State Forest Lands				
Purchase and Transfer	625,178	595,241	603,025	563,604
Community College Forest Reserve[5/]				
Community College Forest Reserve Lands	3,339	3,339	3,339	3,079
Total for all Trust Lands	**2,852,055**	**2,078,415**	**1,446,733**	**1,337,065**

Data Sources:
[1/] DNR 2001 (various tables).
[2/] DNR Geographic Information System data 2003.
[3/] DNR Geographic Information System data identifies 79,672 acres in 9 other categories: Administrative Site, Tidelands - 2nd Class, Land Bank, CEP&RI Transferred, Under Contract to Private Party, Natural Area Preserve, Natural Resources Conservation Area, Non-specific Non-fiduciary Trust, and Water Pollution Control Division Trust Land.
[4/] These data compiled from the OPTIONS model identify 50,558 acres in the 9 other categories identified in footnote 3.
[5/] Lands managed per Revised Code of Washington (RCW) 79.02.420, which specifies the management of, and disposition of revenues from, these lands.
Note: Numbers rounded; when added may not equal total.

Annual westside timber harvest is presented by trust beneficiary for Fiscal Year 1998 to Fiscal Year 2002 in Table 4.11-2. Total westside harvest ranged from 412 million board feet in Fiscal Year 2002 to 542 million board feet in Fiscal Year 1999, with an annual average of 479 million board feet. Federal grant trust land accounted for approximately 41 percent of the average annual total. State forest lands accounted for about 58 percent, with community college forest reserve lands and other comprising the remaining 1 percent.

Table 4.11-2. Annual Westside Timber Harvest by Trust Beneficiary, Fiscal Year 1998 to Fiscal Year 2002 (million board feet)[1/]

	Fiscal Year[2/]					
	1998	**1999**	**2000**	**2001**	**2002**	**5-year Average**
Federal Grant Trust Lands						
Agricultural School Grant (Washington State University)	8.8	9.9	6.6	4.3	4.1	6.8
Capitol Building Grant[3/]	21.7	23.9	34.2	21.0	30.7	26.3
Charitable, Educational, Penal, and Reformatory Institutions Grant	9.1	11.8	10.7	10.6	11.0	10.6
Common School, Indemnity, and Escheat Grants[3/]	136.4	142.4	137.2	112.4	87.5	123.2
Normal School Grant (Eastern Washington University, Central Washington University, Western Washington University, and The Evergreen State College)[3/]	7.1	2.9	10.2	6.4	11.9	7.7
Scientific School Grant (Washington State University)	22.3	28.0	16.0	17.3	15.3	19.8
University Grants (University of Washington) Original and Transferred[3/]	4.6	6.1	0.8	6.5	2.6	4.1
Federal Grant Trust Land Total	**210.1**	**225.0**	**215.7**	**178.5**	**163.1**	**198.5**
State Forest Lands						
Purchase and Transfer[3/]	266.1	314.6	305.2	249.5	244.5	276.0
Community and Technical College Reserve						
College Reserve	1.8	0.3	0.0	0.8	1.3	0.8
Other	0.5	2.4	4.4	6.7	3.3	3.5
Total for all Beneficiaries	**478.5**	**542.3**	**525.3**	**435.5**	**412.2**	**478.8**

Notes:
1/ Timber is sold before it is harvested. Timber sale contracts average 2 years in length, with timber harvest schedules determined by individual purchasers. Revenues are generated when timber is harvested.
2/ DNR's Fiscal Year extends from July 1 through June 30. Fiscal Year 2002, for example, extended from July 1, 2001, through June 30, 2002.
3/ All harvest volume for state forest purchase lands designated as university repayment and state forest repayment are included in the state forest purchase total.
Data Source: DNR Report TSC312.

Federal grant trust lands located in westside counties generated an annual average income of $83.2 million between Fiscal Year 1998 and Fiscal Year 2002, with the common school grant lands accounting for 63 percent or $52.6 million of this total (Table 4.11-3). Total annual income generated by federal grant trust lands in westside counties has fluctuated over the last 5 years, ranging from $52.1 million in Fiscal Year 2002 to $104.2 million in Fiscal Year 1998 (Table 4.11-3).

Table 4.11-3. Annual Westside Timber Income Generated by Trust Beneficiary, Fiscal Year 1998 to Fiscal Year 2002 ($ million)[1/]

	Fiscal Year[2/]					
	1998	**1999**	**2000**	**2001**	**2002**	**5-year Average**
Federal Grant Beneficiaries[3/]						
Agricultural School Grant (Washington State University)	3.9	4.1	2.4	1.5	1.0	2.6
Capitol Building Grant[4/]	8.4	9.2	11.3	6.6	9.7	9.0
Charitable, Educational, Penal, and Reformatory Institutions Grant	4.4	4.9	4.5	3.4	3.8	4.2
Common School, Indemnity, and Escheat Grants[4/]	69.4	66.0	55.6	44.8	27.2	52.6
Normal School Grant (Eastern Washington University, Central Washington University, Western Washington University, and The Evergreen State College)[4/]	5.5	3.6	7.0	4.3	5.2	5.1
Scientific School Grant (Washington State University)	9.2	11.7	5.7	5.6	4.0	7.2
University Grants (University of Washington) Original and Transferred[5/]	3.6	4.2	1.4	2.0	1.3	2.5
Federal Grant Beneficiaries Total	**104.2**	**103.7**	**87.9**	**68.2**	**52.1**	**83.2**
State Forest Beneficiaries						
Purchase and Transfer[4/5/]	124.9	136.1	114.9	86.8	77.7	108.1
Community College Forest Reserve						
Community College Forest Reserve Lands	0.2	0.0	0.0	0.1	0.2	0.1
Total for all Beneficiaries	**229.3**	**239.8**	**202.8**	**155.0**	**130.0**	**191.4**

Data Source: DNR Report TSC312.
[1/] Annual income figures are adjusted for inflation and presented in 2002 dollars.
[2/] DNR's Fiscal Year extends from July 1 through June 30. Fiscal Year 2002, for example, extended from July 1, 2001 through June 30, 2002.
[3/] Gross timber revenue before reduction for management funds (Resource Management Cost Account and Forest Development Account).
[4/] Revenue from state forest purchase lands designated state forest repayment are split:12.67% to school grant; 4.83% to capitol grant; 15.45% to normal grant, and 67.05% to state forest.
[5/] Revenue from state forest purchase lands designated university repayment are split: 32.14% to university grant and 67.86% to state forest.

On average, statewide DNR timber sale revenue accounted for approximately 73 percent of annual federal grant trust land income between Fiscal Years 1998 and 2002. This percentage ranged from 61.5 percent in Fiscal Year 2001 to 85.1 percent in Fiscal Year 1998. Timber sale revenue as a share of annual federal grant trust lands income declined between Fiscal Years 1998 and 2001, but increased from 61.5 percent in Fiscal Year 2001 to 71.2 percent in Fiscal Year 2002 (Table 4.11-4). The decline between Fiscal Years 1998 and 2001 was particularly notable for the common school grant, which saw timber sale revenue decrease from 82.3 percent of total trust revenue in 1998 to just 53.5 percent in Fiscal Year 2001 (Table 4.11-4). About half of this decline is the result of increases in non-timber revenue resulting from the purchase of timberlands by the legislature for

Table 4.11-4. Timber Sale Revenue as a Proportion of Total Annual Trust Income by Trust Beneficiary, Fiscal Year 1998 to Fiscal Year 2002 (Percent)

	Fiscal Year					
	1998	1999	2000	2001	2002	5-year Average
Federal Grant Trust Lands						
Agricultural School Grant (Washington State University)	95.8	94.8	93.5	83.4	86.5	90.8
Capitol Building Grant	96.0	97.5	98.1	98.2	96.1	97.2
Charitable, Educational, Penal, and Reformatory Institutions Grant	80.3	78.3	81.8	71.4	82.1	78.8
Common School, Indemnity, and Escheat Grants	82.3	68.8	64.6	53.5	62.4	66.3
Normal School Grant (Eastern Washington University, Central Washington University, Western Washington University, and The Evergreen State College)	95.3	96.4	98.5	98.0	96.6	96.9
Scientific School Grant (Washington State University)	93.4	95.0	94.0	86.2	82.2	90.2
University Grants (University of Washington) Original and Transferred	90.7	93.8	80.3	88.8	81.8	87.1
Federal Grant Trust Land Total	**85.1**	**75.5**	**71.7**	**61.5**	**71.2**	**73.0**
State Forest Lands						
Purchase and Transfer	98.9	99.4	99.5	99.4	98.0	99.0
Total for all Trust Lands	**91.3**	**86.7**	**83.3**	**76.7**	**83.0**	**84.2**

Data Sources: DNR 1998, 1999, 2000, 2001, 2002a.
Note: DNR's Fiscal Year extends from July 1 through June 30. Fiscal Year 2002, for example, extended from July 1, 2001, through June 30, 2002.

transfer out of trust ownership into parks and other non-consumptive uses through the trust land transfer program. This program is limited to the common school, indemnity, and Escheat grants lands.

State Forest Lands

Overview

Beginning in the 1930s, the state acquired about 620,000 acres of forestlands that had been privately owned. Most of these lands had been logged and abandoned, and reverted to county ownership for non-payment of taxes. The predominant attitude toward the state's forest during the early part of the last century was much different than it is today. After the timber was removed from privately owned lands either by harvest, fire, or both, the remaining land had little or no economic value. After harvesting, many landowners abandoned the lands and stopped paying taxes. These tax delinquent lands reverted to the counties who were unable to sell the land because there was no market. The counties were even less able than the private sector to manage them. Most of these lands, then in bad condition, simply sat idle. The state Legislature, concerned about reforestation of these lands to provide future timber supply, provided legislative direction on how to manage and authorize these lands in the 1921 Reforestation Act. These "state forest lands," formerly known as Forest Board lands, are defined in RCW 79.02.010(10).

In 1923, the Legislature authorized the use of utility bonds of $200,000 to acquire forestland and to pay for reforestation. The bonds were to be repaid from management revenues from these lands rather than the state's general fund. The Legislature authorized the acquisition of state forest purchase lands for not more than $6.00 per acre for forested lands and $2.00 per acre for logged over lands. These lands are known as state forest purchase lands.

In 1927, the Legislature passed a law providing that the counties could transfer tax delinquent forestlands to the state to be managed as state forests. No lands were transferred until 1935, when the Legislature passed legislation requiring the counties to transfer tax delinquent land suitable for forestry uses to the state to be managed in trust as part of the state forest system. These lands are also known as state forest transfer lands.

In that year (1935), the Legislature authorized an additional $300,000 in utility bonds to acquire additional state forest purchase lands. However, the amount that could be paid for these lands was reduced to $1.00 for logged over lands and $3.00 for forested lands. The Legislature authorized issuance of additional bonds each biennium through 1949.

DISTRIBUTION OF STATE FOREST REVENUES

Below is a description of the state statutes governing the distribution of revenues raised by DNR on state forest lands.

State Forest Transfer Revenues

RCW 79.64.110 provides direction for the distribution of any moneys derived from state forest lands, and RCW 79.64.110 (1) directs the distribution of revenues generated from state forest transfer lands. RCW 79.64.110 (1)(a) reads as follows:

> The expense incurred by the state for administration, reforestation, and protection, not to exceed twenty-five percent, which rate of percentage shall be determined by the board, must be returned to the forest development account in the State General Fund.

The Board of Natural Resources has set the current Forest Development Account deduction at 22 percent, and the remaining 78 percent is distributed to the counties per RCW 79.64.110 (1)(b):

> Any balance remaining must be paid to the county in which the land is located to be paid, distributed, and prorated, except as otherwise provided in this section, to the various funds in the same manner as general taxes are paid and distributed during the year of payment.

Most counties (the exceptions are Skamania and Wahkiakum Counties – see RCW 79.64.110 (1)(c) below) are required to distribute the revenue they receive from State Forest Transfer lands to the various taxing districts in the same manner (paid, distributed, and prorated) as general property taxes are distributed. The actual distribution of revenue from a timber sale depends on which taxing districts the harvest is located in and the tax rates during the year that harvest occurred.

In 2003, the average distribution of property taxes statewide was 55.8 percent to schools, 17.5 percent to the counties general fund (including roads), 13.8 percent to cities and towns, and 13 percent to various local taxing districts (ports, fire, library, hospital, emergency medical, and parks) (Washington State Department of Revenue 2004). The average distribution varies from county to county and from year to year. The proportion of state forest transfer revenue distributed to schools is an offset to State General Fund expenditures; that is, the moneys received by the schools from the State General Fund are reduced by the amount they receive from state forest transfer lands.

RCW 79.64.110 (1)(c) provides an exception, and reads as follows:

> Any balance remaining, paid to a county with a population of less than sixteen thousand, must first be applied to the reduction of any indebtedness existing in the current expense fund of the county during the year of payment.

Of the 19 counties that receive State Forest Transfer revenues, only 2 have populations of less than 16,000: Skamania and Wahkiakum Counties. For these two counties, the county's portion of revenues from State Forest Transfer Lands is distributed first to the counties current expense fund to pay any existing indebtedness. Any excess is distributed in accordance with the general property taxes distribution. All of the revenue to Wahkiakum County and most of that to Skamania County has gone to their general fund. The result is that these counties retain more revenue, rather than having a large portion offset by the comparable withholding of State General Fund revenues to schools. In addition, they have more control over how those revenues are expended.

State Forest Purchase Revenues

RCW 79.64.110 (2) directs the distribution of revenues generated from State Forest Purchase lands. RCW 79.64.100 (2)(a) reads as follows:

> Fifty percent shall be placed in the forest development account.

Unlike the management fund deduction for the state forest transfer lands, the deduction for state forest purchase lands is a fixed amount rather than a maximum.

The remaining 50 percent is distributed to the counties per RCW 79.64.110 (2)(b):

> Fifty percent shall be prorated and distributed to the State General Fund, to be dedicated for the benefit of the public schools, and the county in which the land is located according to the relative proportions of tax levies of all taxing districts in the county. The portion to be distributed to the State General Fund shall be based on the regular school levy rate under RCW 84.52.065 and the levy rate for any maintenance and operation special school levies. With regard to the portion to be distributed to the counties, the department shall certify to the state treasurer the amounts to be distributed within seven working days of receipt of the money. The state treasurer shall distribute funds to the counties four times per month, with no more than ten days between each payment date. The money distributed to the

county must be paid, distributed, and prorated to the various other funds in the same manner as general taxes are paid and distributed during the year of payment.

The portion distributed directly to the general fund is prorated based on the regular school, and maintenance and operation special school levies. The money distributed to the county is distributed to the taxing districts other than the schools in the same manner (paid, distributed, and prorated) as property taxes are distributed.

While the distribution of the revenues remaining after the forest development account deduction may seem different for the purchase and transfer lands, in fact only the administrative route is different, and the resulting distribution is the same. This is because the proportion distributed to the schools for state forest transfer is an offset to general fund revenue, while the state forest purchase portion is transferred directly to the State General Fund.

Revenues Generated from State Forest Lands

There were approximately 625,000 acres of state forest lands in the state of Washington in 2001, with the majority (603,000 acres) located in westside counties (Table 4.11-1). State forest lands (purchase and transfer) located in westside counties generated an average annual income of $108.1 million between Fiscal Year 1998 and Fiscal Year 2002, about 56 percent of the total income generated by DNR on western Washington forested trust lands (Table 4.11-3). Total annual income generated by state forest lands has fluctuated over the last 5 years, ranging from $77.7 million in 2002 to $136.1 million in 1999 (Table 4.11-3). On average, timber sale revenue accounted for 99.0 percent of statewide annual state forest lands income between Fiscal Years 1998 and 2002 and stayed relatively constant over this period (Table 4.11-4).

Revenue to beneficiaries (County and General Fund) from state forest (purchase and transfer) lands are presented by county for Fiscal Years 1998 through 2002 in Table 4.11-5. In contrast to the state forest revenue data summarized in Table 4.11-3, these data are for all revenue sources, not just timber. These data show that revenues can fluctuate quite dramatically from year-to-year, with the westside county total ranging from $59.2 million in Fiscal Year 2002 to $110.8 million in Fiscal Year 1999 (Table 4.11-5). Total annual average payments from Fiscal Years 1998 through 2002 ranged from $0.8 million in Kitsap County to $10.5 million in Skagit County.

Annual average revenue data from all sources for 1998 through 2002 are compared with annual average general property taxes for the same period in Table 4.11-6. Total state forest revenues are compared with general property taxes by county because, with the exception of Skamania and Wahkiakum Counties, revenues are distributed as regular property taxes where the revenue is generated and during the years the revenues are generated. It should, however, be noted that the state forest income data are by fiscal year, while the general property tax data are presented for calendar years. Total forest income represents approximately 2 percent of total general property taxes for the 17 westside

Table 4.11-5. Revenue from all Sources to Beneficiaries (County and General Fund) from State Forest Lands in Westside Counties ($ million)[1/2]

	Fiscal Year					5-year
County	**1998**	**1999**	**2000**	**2001**	**2002**	**Average**
Clallam	9.6	13.5	7.3	6.0	5.4	8.4
Clark	5.6	8.0	4.3	2.3	3.2	4.7
Cowlitz	3.0	2.5	3.4	2.1	3.8	3.0
Grays Harbor	4.5	2.9	4.8	3.6	4.5	4.1
Jefferson	0.5	2.5	1.4	1.6	0.8	1.4
King	2.8	1.9	2.7	1.4	1.7	2.1
Kitsap	1.6	0.9	0.3	1.1	0.1	0.8
Lewis	10.2	18.4	13.1	5.3	2.7	9.9
Mason	3.0	2.2	2.8	2.0	1.8	2.4
Pacific	3.8	7.9	4.4	2.9	3.4	4.5
Pierce	1.1	1.8	0.6	1.1	1.8	1.3
Skagit	11.2	12.7	11.4	6.3	10.8	10.5
Skamania	1.4	3.8	2.0	1.2	0.3	1.7
Snohomish	9.5	9.4	13.9	13.4	5.7	10.4
Thurston	12.6	10.8	9.4	9.7	6.3	9.8
Wahkiakum	5.2	2.2	1.8	0.9	3.0	2.6
Whatcom	7.2	9.5	2.6	6.9	3.9	6.0
Total	**93.0**	**110.8**	**86.2**	**68.0**	**59.2**	**83.4**

Source DNR Annual Reports.
1/ In contrast to the state forest revenue data summarized in Table 4.11-3, these data are for all revenue sources, not just timber, but do not include revenue to the management fund (forest development account). These data also include revenue transferred directly to State General Fund.
2/ Annual income figures are adjusted for inflation and presented in 2002 dollars.

counties combined (Table 4.11-6). This percentage varies considerably by county, ranging from less than 1 percent of general property taxes in King, Kitsap, and Pierce Counties to more than 100 percent in Wahkiakum County (Table 4.11-6).

Community College Forest Reserve

In addition to federal grant and state forest lands, DNR also manages a small amount (3,339 acres) of forestlands for community colleges (Table 4.11-1). These lands are addressed in the 1992 Forest Plan, and are managed per RCW 79.02.420, which specifies the management of, and disposition of revenues from, these lands.

Table 4.11-6. Annual Average Total State Forest Income as a Proportion of Annual Average General Property Taxes by Westside County, 1998 to 2002

County	$ Million State Forest Income Average FY 1998-2002[1/2/]	$ Million General Property Taxes Average CY 1998-2002[2/3/]	Ratio of State Forest Revenues to General Property Taxes
Clallam	8.4	41.0	20.4%
Clark	4.7	308.6	1.5%
Cowlitz	3.0	77.9	3.8%
Grays Harbor	4.1	46.8	8.7%
Jefferson	1.4	29.8	4.6%
King	2.1	2,164.8	0.1%
Kitsap	0.8	198.0	0.4%
Lewis	9.9	48.6	20.4%
Mason	2.4	44.5	5.3%
Pacific	4.5	19.0	23.5%
Pierce	1.3	617.7	0.2%
Skagit	10.5	100.8	10.4%
Skamania[4/]	1.7	7.4	23.6%
Snohomish	10.4	575.0	1.8%
Thurston	9.8	184.9	5.3%
Wahkiakum[4/]	2.6	2.5	105.0%
Whatcom	6.0	150.1	4.0%
Total	**83.4**	**4,617.4**	**1.8%**

Source: DNR Annual Reports 1998, 1999, 2000, 2001, and 2002a; Washington Department of Revenue 2004.
FY = Fiscal Year; CY = Calendar Year
1/ In contrast to the state forest revenue data summarized in Table 4.11-3, these data are for all revenue sources, not just timber, do not include revenues to the management fund (FDA). These data also include revenue transferred directly to State General Fund.
2/ Annual income figures are adjusted for inflation and presented in 2002 dollars.
3/ General property tax collection including delinquent payments in year received.
4/ Revenues to counties with a population of less than 16,000 are applied to the county's current expense fund.

4.11.3.2 Transportation Infrastructure

The Final Environmental Impact Statement (EIS) for the DNR Forest Resource Plan indicated that DNR operated about 12,000 miles of roads (throughout both western and eastern Washington), building approximately 60 miles of new road each year. About 7,500 miles of these roads are used for transportation, with another 3,600 miles maintained only for fire prevention and management. Current estimates from the DNR Forest Practices Transportation Layer (2004) indicate there are 14,000 statewide road miles on DNR-managed lands, with just over 8,000 miles of road in western Washington (see Road Density Analysis in Chapter 4, Section 4.6.3 on Geomorphology, Soils, and Sediment). DNR decommissions roads that are no longer needed.

Timber harvest, fire control, and recreation activities all generate traffic on DNR forest roads. The largest single source of traffic is associated with DNR's management of forested trust lands, although recreation access may be the largest use in some areas. Traffic from these activities extends from the network of DNR and private forest roads onto county roads, as well as state and interstate highways. County and state roads are affected to varying degrees by logging trucks and other traffic generated from timber harvesting on forested trust lands, as well as timber harvesting on other types of land ownership.

Timber harvest data are presented by westside county for forested trust lands in Table 4.11-7.

This table also presents forested trust land harvest as a percentage of total harvest (state, federal, and private) by county. Data are presented for 2002, with the annual average for 1998 to 2002 also provided. Harvest volumes from all lands in 2002 were lower than the 1998 to 2002 average for all but four westside counties. Harvest volumes from trust lands in 2002 were higher than the 1998 to 2002 average in 7 of the 19 westside counties (Table 4.11-7). These data are all presented by calendar year.

Table 4.11-7. Forested Trust Lands Compared to Total Timber Harvest in Western Washington by County, Calendar Year 1997 to Calendar Year 2002 (million board feet)

	2002			1998-2002 Average		
County	**Forested Trust Land Harvest**	**Total Harvest[1/]**	**State as a % of Total**	**Forested Trust Land Harvest**	**Total Harvest[1/]**	**State as a % of Total**
Clallam	19.0	206.9	9.2	35.5	246.9	14.4
Clark	17.7	52.4	33.8	22.9	76.1	30.1
Cowlitz	29.1	217.3	13.4	30.0	254.4	11.8
Grays Harbor	41.6	502.7	8.3	38.2	500.0	7.6
Island	0.0	2.3	0.0	0.0	14.0	0.0
Jefferson	19.0	73.6	25.8	15.4	71.8	21.5
King	19.0	91.0	20.9	13.2	141.1	9.3
Kitsap	0.4	19.1	2.0	2.8	28.4	9.7
Lewis	13.2	452.8	2.9	47.3	442.6	10.7
Mason	20.2	134.9	14.9	20.2	167.3	12.1
Pacific	25.8	265.3	9.7	37.0	294.5	12.6
Pierce	20.1	165.3	12.2	15.9	211.9	7.5
San Juan	0.0	0.6	0.0	0.0	1.9	0.0
Skagit	57.0	124.3	45.9	45.0	146.1	30.8
Skamania	0.8	32.0	2.6	11.6	42.3	27.3
Snohomish	40.1	90.8	44.2	41.4	120.6	34.3
Thurston	26.2	97.6	26.9	45.3	114.0	39.8
Wahkiakum	15.6	69.0	22.6	15.1	86.9	17.4
Whatcom	33.0	106.3	31.0	30.2	93.9	32.2
Total Westside Counties	**397.8**	**2,704.1**	**14.7**	**467.0**	**3,054.8**	**15.3**

Data Source: DNR Washington Timber Harvest Reports 1998, 1999, 2000, 2001, and 2002a.

[1/] The total timber harvest volumes presented in this table include timber harvest from all land ownerships, including Native American, Forest Industry, Large Private, Small Private, State (DNR-managed lands), Other Non-federal National Forest, and Other Federal.

Assuming an average load per logging truck of 4.5 thousand board feet suggests that harvest from all lands in Grays Harbor County in 2002, for example, generated about 111,700 logging truck trips. Using the same assumption, harvest from state lands in Snohomish County in the same year generated about 20,200 logging truck trips. It should be noted that each logging truck trip consists of two parts: one way with a full load, and one way empty.

4.11.4 Environmental Effects

4.11.4.1 Forested Trust Land and Trust Beneficiaries

This section summarizes projected harvest levels by Alternative. It compares these with annual average harvest levels over the past 5 years to offer some insight into the potential effects of the proposed Alternatives on trust revenues. This analysis allows for comparison among Alternatives, and provides some indication of their relative value. It does not, however, attempt to project future revenues. Actual revenues will be determined by a number of factors, including prices for timber that are determined in the wider marketplace. While projected annual average harvest allows a comparison among Alternatives, it does not take into account variations in harvest costs among Alternatives. Potential purchasers factor expected harvest costs into the amount they bid for a particular timber sale, with higher cost sales receiving lower bids. As a result, it should be noted that while projected harvest levels allow some comparison among Alternatives, increases in harvest do not necessarily represent a commensurate increase in revenue.

Projected 2004 to 2013 annual average harvests are presented, by trust beneficiary and Alternative, in Table 4.11-8. The largest projected total harvest would occur under Alternative 3, with a total harvest of about 663 million board feet, followed by Alternative 5 (648.3 million board feet), the Preferred Alternative (636.1 million board feet), Alternative 2 (536.7 million board feet), Alternative 4 (410.9 million board feet), and Alternative 1 (396.2 million board feet). Projected average annual harvests for 2004 through 2013 for Alternatives 2, 3, 5, and the Preferred Alternative are higher than the actual average annual harvest from 1998 to 2002.

The largest amount of harvest would occur on state forest lands and common school, indemnity, and escheat grant lands under all Alternatives. State forest lands range from 45 percent of the total projected volume under the Preferred Alternative, to 54 percent under Alternative 3. The common school, indemnity, and escheat grant lands range from 27 percent of the projected total under Alternative 3 to 33 percent under Alternative 2. Projected average annual harvests for the common school, indemnity, and escheat grant lands are higher than the 1998 to 2002 annual average for all Alternatives, with the exception of Alternatives 1 and 4.

Table 4.11-8. Projected Annual Average Westside Harvest by Trust Beneficiary and by Alternative, 2004 to 2013 (million board feet)

Trust Beneficiary	5-Year Westside Annual Average[1/]	Alternative 1	2	3	4	5	PA
Federal Grant Trust Lands							
Agricultural School Grant (Washington State University)	6.8	9.3	9.1	7.7	12.2	11.4	16.8
Capitol Building Grant	26.3	33.9	39.5	47.2	29.1	57.6	57.8
Charitable, Educational, Penal, and Reformatory Institutions Grant	10.6	14.2	15.2	17.2	11.6	16.3	19.4
Common School, Indemnity, and Escheat Grants	123.2	114.3	176.2	182.2	120.3	203.5	198.1
Normal School Grant (Eastern Washington University, Central Washington University, Western Washington University, and The Evergreen State College)	7.7	6.4	11.7	11.2	7.4	12.6	9.5
Scientific School Grant (Washington State University)	19.8	22.7	21.9	28.1	22.9	26.7	31.6
University Grants (University of Washington) Original and Transferred	4.1	2.1	12.8	10.0	4.2	14.5	12.5
Federal Grant Trust Land Total	**198.5**	**202.9**	**286.3**	**303.7**	**207.7**	**342.6**	**345.6**
State Forest Lands							
Purchase and Transfer	276.0	192.0	249.6	359.1	202.1	305.2	289.4
Community and Technical College Reserve							
College Reserve	0.8	1.4	0.9	0.3	1.2	0.5	1.1
Total	**478.8**	**396.2**	**536.7**	**663.1**	**410.9**	**648.3**	**636.1**

PA = Preferred Alternative
[1/] This is the annual average for forested trust lands in westside counties for 1998 to 2002 (for individual years, see Table 4.11-2). These data are by fiscal year. Projected annual average harvest data are by calendar year.
Data Source: Model output data – timber flow levels.

Federal Grant Lands

Projected annual average harvest levels for 2004 to 2013 on federal grant lands are higher than the 1998 to 2002 actual annual average under all Alternatives (Table 4.11-8). Projected annual average harvest levels over this period range from 202.9 million board feet under Alternative 1 to 345.6 million board feet under the Preferred Alternative. There is some variation by beneficiary. Projected harvest levels are, for example, highest under the Preferred Alternative for the agricultural school grant; capitol building grant; charitable, educational, penal, and reformatory institutions grant; and scientific school grant lands. Projected harvest levels are highest for the remaining three federal grant land groups (common school, indemnity, and escheat grant; normal school grantl; and university grant) under Alternative 5 (Table 4.11-8).

State Forest Lands

Unlike federal grant trust land revenues, which are distributed to the same beneficiary regardless of where the harvest takes place, revenues from state forest lands are distributed based on the taxing district in which the harvested land is located. With the exception of Skamania and Wahkiakum Counties, revenues to the counties are distributed based on the distribution of general property taxes, where the revenue was generated, and within the year the revenues were generated. Within a county, sales may benefit one taxing district or another based on the sale location. Because a local taxing district only benefits when harvest occurs on land within that taxing district, it may only benefit once or twice per rotation. As a result, revenue distribution to counties and to junior taxing districts within those counties is expected to vary from year-to-year under all of the proposed Alternatives and is difficult to accurately predict. In addition, about half of the revenues to counties benefit the state's general fund either directly (purchase lands) or as an offset to State General Funds to the schools (transfer lands). Therefore, not only is it difficult to predict where harvest will occur in the future, it is also difficult to predict what effect this revenue would have on the built environment.

The following discussion of projected average annual state forest land harvest by county allows a relative comparison to be made by Alternative and county. These modeling results do not provide precise harvest schedules, but they can represent a likely distribution of harvest levels over time at the county level. More precise short-term harvest schedules will be developed through operational level planning.

Projected annual average harvest levels for 2004 to 2013 for state forest lands are higher than the 1998 to 2002 annual average under Alternatives 3 and 5 and the Preferred Alternative. The geographic distribution of the projected harvest over this period would vary by Alternative. Projected harvest under Alternative 3 is largest in Thurston County (44.6 million board feet) followed by Clallam (39.7 million board feet) and Lewis (35.3 million board feet) counties (Table 4.11-9). Under Alternative 5, projected harvest is largest in Clallam County (66.3 million board feet) followed by Skagit (36.5 million board feet) and Snohomish (26.6 million board feet) counties. Projected harvest under the Preferred Alternative is largest in Skagit County (49.1 million board feet) followed by Clallam (45.7 million board feet) and Snohomish (27 million board feet) counties. Projected harvest under Alternatives 2 and 4 is highest in Skagit County, followed by Snohomish and Thurston counties. Under Alternative 1, projected harvest levels are highest in Skagit County, followed by Thurston and Snohomish Counties (Table 4.11-9).

The ratio of annual average state forest revenues to general property taxes from 1998 through 2002 varied by county and also by year (Tables 4.11-5 and 4.11-6). Annual average ratios over this period ranged from less than 1 percent of general property taxes in King, Kitsap, and Pierce Counties to more than 100 percent in Wahkiakum County. This ratio was also above 20 percent in Clallam, Lewis, Pacific, and Skamania Counties (Table 4.11-6). Projected annual average harvest levels for 2004 through 2013

Table 4.11-9. Projected Annual Average Harvest on State Forest Lands[1/] by County and Alternative, 2004 to 2013 (million board feet)

County	5-yearAnnual Average[2/]	Alternative 1	2	3	4	5	PA
Clallam	29.1	12.7	25.5	39.7	20.3	66.3	45.7
Clark	13.1	12.3	14.7	28.3	10.0	15.9	12.4
Cowlitz	8.4	4.8	6.0	11.2	5.0	5.8	4.9
Grays Harbor[3/]	21.8	11.3	10.2	22.5	8.5	14.7	15.5
Jefferson	3.6	5.3	6.2	15.6	3.3	7.2	6.1
King	5.6	8.9	7.8	6.3	5.6	10.8	10.5
Kitsap	2.1	2.8	2.7	5.8	2.4	3.2	2.1
Lewis	29.1	16.9	22.1	35.3	19.1	23.6	19.5
Mason	6.9	8.3	8.9	30.1	7.3	9.8	5.0
Pacific[4/]	18.2	6.0	10.8	12.7	13.3	14.4	16.9
Pierce[4/]	3.9	6.0	7.5	5.1	2.0	7.3	9.4
Skagit	31.9	30.0	35.2	27.7	31.8	36.5	49.1
Skamania	5.5	5.4	16.9	28.5	3.0	20.4	25.9
Snohomish	33.9	22.9	27.7	18.9	27.1	26.6	27.0
Thurston[3/]	38.2	23.5	27.2	44.6	24.3	22.1	18.9
Wahkiakum	7.1	3.6	5.1	8.7	5.8	6.9	5.7
Whatcom	17.7	11.3	15.1	18.2	13.5	14.0	14.9
Total	**276.0**	**192.0**	**249.6**	**359.1**	**202.1**	**305.2**	**289.4**

PA = Preferred Alternative
[1/] State Forest lands per RCW 79.02.010(10) are formerly known as Forest Board Lands.
[2/] This is the annual average for CY 1998 to CY 2002 as historical state forest harvest by county is not available by Fiscal Year.
[3/] Five-year annual average includes all volume harvested from Forest Board Purchase lands designated as Forest Board Repayment Lands within the county
[4/] Five-year annual average includes all volume harvested from Forest Board Purchase lands designated as University Repayment Lands within county
Data Source: Model output data – timber flow levels; DNR 2002a

for these counties vary substantially by Alternative. Projected harvest levels in Wahkiakum County range from 3.6 million board feet under Alternative 1 to 6.9 million board feet under Alternative 5. In Clallam County, projected harvest levels range from 12.7 million board feet under Alternative 1 to 66.3 million board feet under Alternative 5. Projected harvest levels in Lewis County range from 16.9 million board feet under Alternative 1 to 35.3 million board feet under Alternative 3. In Pacific County, projected harvest ranges from 6 million board feet under Alternative 1 to 16.9 million board feet under the Preferred Alternative. Projected harvest in Skamania County ranges from 3 million board feet under Alternative 4 to 28.5 million board feet under Alternative 3 (Table 4.11-9).

The relationship between projected annual average harvest levels for 2004 through 2013 and actual annual harvest levels between 1998 and 2002 also varies by county and Alternative. In Clallam County, annual average projected harvest levels would be higher than actual annual average 1998 to 2002 harvest levels under Alternatives 3 and 5 and the Preferred Alternative, and lower than the actual annual average under the other Alternatives. In Lewis and Wahkiakum Counties, projected annual average harvest levels would be lower than actual levels under all Alternatives, with the exception of Alternative 3. Projected annual average harvest levels would be lower than actual 1998 to

2002 levels under all Alternatives in Pacific County. In Skamania County, projected annual average harvest levels would be higher under all of the Alternatives, with the exceptions of Alternatives 1 and 4 (Table 4.11-9).

4.11.4.2 Transportation Infrastructure

The following analysis considers projected average annual harvest by Alternative and county as a general indication of the relative potential impact of the proposed Alternatives on transportation infrastructure. Assuming an average load of 4.5 thousand board feet per logging truck, Alternatives with larger projected harvest volumes would result in more logging traffic with larger associated potential effects to transportation infrastructure. The following discussion of projected average annual harvest by county allows a relative comparison to be made by Alternative and county, but does not attempt to quantify these potential effects in terms of projected infrastructure improvement costs. Although, as previously noted, the modeling results do not produce precise harvest schedules; the results can represent a likely distribution of harvest levels over time at the county level. More precise short-term harvest schedules will be developed through operational level planning.

Projected annual average harvest is presented by county for 2004 to 2013 in Table 4.11-10. These data are based on general projected harvest location for forest grant lands, as well as state forest lands. Alternative 3 would result in the largest total average annual volume harvested, followed by Alternative 5, the Preferred Alternative, Alternatives 2, 4, and 1 in that order. Total projected average annual harvest for 2004 to 2013 is higher than the 1998 to 2002 annual average under Alternatives 2, 3, and 5, as well as the Preferred Alternative. Based on an estimated 4.5 thousand board feet/logging truck, the number of logging trips generated by the proposed Alternatives would range from approximately 88,000 under Alternative 1 to 147,200 under Alternative 3, compared to a 1998 to 2002 annual average of approximately 103,800. The Preferred Alternative would generate an average of approximately 141,600 trips a year over this period (Table 4.11-11).

The geographic distribution of the projected harvest and associated logging truck traffic over this period would vary by Alternative. Under Alternative 5 and the Preferred Alternative, annual average projected harvest is largest in Clallam County, with Alternative 5 and the Preferred Alternative generating about 26,000 and 18,900 logging trips, respectively. Projected harvest under Alternative 3 is largest in Mason and Lewis Counties, with an estimated annual average 13,800 and 13,500 logging trips, respectively. Under Alternatives 1 and 4, annual average projected harvest is largest in Skagit and Snohomish Counties, with Alternatives 1 and 4 generating about 10,100 and 11,200 logging trips in Skagit County, respectively. Projected harvest under Alternative 2 is largest in Jefferson and Skagit Counties, with an estimated annual average 11,900 and 11,200 logging trips, respectively (Table 4.11-11).

Table 4.11-10. Projected Annual Average Harvest by Westside County, by Alternative, 2004 to 2013 (million board feet)

County	5-YearAnnual Average[1/]	Alternative					
		1	2	3	4	5	PA
Clallam	35.5	22.6	38.0	56.3	28.4	116.9	84.9
Clark	22.9	30.5	36.0	56.0	23.2	34.0	40.3
Cowlitz	30.0	32.6	28.4	45.6	27.3	30.9	29.5
Grays Harbor	38.2	25.1	45.4	52.4	35.2	38.7	44.2
Jefferson	15.4	9.9	54.4	56.3	10.7	67.8	30.2
King	13.2	14.2	12.6	14.7	8.7	25.5	23.8
Kitsap	2.8	5.9	5.1	9.8	3.8	5.9	4.0
Lewis	47.3	41.1	48.7	63.3	34.0	56.0	49.4
Mason	20.2	28.9	25.7	58.9	21.5	29.7	17.9
Pacific	37.0	15.0	23.0	25.4	35.2	32.8	61.0
Pierce	15.9	12.8	12.8	8.7	4.5	17.6	16.1
San Juan	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Skagit	45.0	42.9	48.7	33.9	47.2	45.9	64.3
Skamania	11.6	10.7	30.0	44.3	6.8	41.5	41.4
Snohomish	41.4	41.4	45.4	29.1	42.9	35.0	47.3
Thurston	45.3	29.9	36.8	55.9	30.8	28.3	25.6
Wahkiakum	15.1	7.9	8.1	18.8	21.6	13.4	29.8
Whatcom	30.2	24.9	37.7	33.7	29.2	28.5	26.4
Total	**467.0**	**396.3**	**536.8**	**663.1**	**411.0**	**648.4**	**636.1**

PA = Preferred Alternative
[1/] This is the annual average for Calendar Year 1998 to Calendar Year 2002 (see Table 4.11-7) because historical harvest by county is not available by Fiscal Year.
Data Source: Model output data – timber flow levels; DNR 2002a.

Table 4.11-11. Projected Annual Average Logging Truck Traffic by Westside County, by Alternative, 2004 to 2013 (number of trips[1/])

County	5-Year Annual Average[2/]	Alternative 1	2	3	4	5	PA
Clallam	7,900	5,000	8,400	12,500	6,300	26,000	18,900
Clark	5,100	6,800	8,000	12,400	5,200	7,600	9,000
Cowlitz	6,700	7,200	6,300	10,100	6,100	6,900	6,600
Grays Harbor	8,500	5,600	10,100	11,600	7,800	8,600	9,800
Jefferson	3,400	2,200	12,100	12,500	2,400	15,100	6,700
King	2,900	3,200	2,800	3,300	1,900	5,700	5,300
Kitsap	600	1,300	1,100	2,200	800	1,300	900
Lewis	10,500	9,100	10,800	14,100	7,600	12,400	11,000
Mason	4,500	6,400	5,700	13,100	4,800	6,600	4,000
Pacific	8,200	3,300	5,100	5,600	7,800	7,300	13,600
Pierce	3,500	2,800	2,800	1,900	1,000	3,900	3,600
San Juan	0	0	0	0	0	0	0
Skagit	10,000	9,500	10,800	7,500	10,500	10,200	14,300
Skamania	2,600	2,400	6,700	9,800	1,500	9,200	9,200
Snohomish	9,200	9,200	10,100	6,500	9,500	7,800	10,500
Thurston	10,100	6,600	8,200	12,400	6,800	6,300	5,700
Wahkiakum	3,400	1,800	1,800	4,200	4,800	3,000	6,600
Whatcom	6,700	5,500	8,400	7,500	6,500	6,300	5,900
Total	**103,800**	**87,900**	**119,200**	**147,200**	**91,300**	**144,200**	**141,600**

PA = Preferred Alternative
[1/] Logging truck traffic is an estimate of logging trips based on an average truckload of 4.5 thousand board feet per truck.
[2/] This is based on the annual average for Calendar Year 1998 to Calendar Year 2002 (see Table 4.11-7).
Data Sources: Model output data – timber flow levels; DNR 2002a.

State and county roads are affected to varying degrees by logging trucks and other traffic associated with timber harvest activities. The Washington State Department of Transportation and the affected counties maintain state and county roads with monies from gasoline taxes, as well as property taxes in the case of county roads. Existing roads on forested trust lands are improved as part of DNR's road development program as traffic conditions warrant. Similarly, public roads are improved when required by increased traffic (DNR 1992b).

Logging companies harvesting timber from forested trust lands must meet Washington State Department of Transportation weight requirements and pay taxes that support road improvements. These taxes include state and federal motor fuel taxes, which currently total 41.4 cents per gallon. The federal portion of these taxes is earmarked for federal highway projects, with most returned to the state to build and maintain interstate highways. State motor fuel taxes are also used for highway purposes only. Timber companies also pay Access Road Revolving Fund fees to the DNR, which pay for forest road maintenance.

DNR regularly meets with local government officials and engineers to discuss the effects of logging-related traffic (DNR 1992b). These measures would help mitigate potential impacts associated with increased road traffic.

4.12 CULTURAL RESOURCES

4.12.1 Summary of Effects

This section analyzes the environmental effects on cultural resources. The analysis examines the effects of prospective changes to current policy, and uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

While there are relative differences among the Alternatives, none is expected to result in any probable significant adverse environmental impacts to cultural resources relative to current conditions. Forest Resource Plan Policy No. 24 requires protection of such resources, and DNR is committed to consulting with Native American tribes and other interested parties about areas of cultural importance to them. These two forms of mitigation are expected to minimize risk to cultural resources.

4.12.2 Introduction

Cultural resources are districts, sites, buildings, structures, and objects that contain evidence of past human activities or that play an active part in the traditional cultures of the disparate ethnic groups that comprise Washington's populace. Legislative bodies at the federal and state levels have recognized cultural resources as important for the education and inspiration of future generations of Americans, whatever their backgrounds.

4.12.3 Affected Environment

4.12.3.1 Archaeological Overview of Western Washington

Despite nearly a century of scientific research in the region, the archaeology of western Washington is not well understood. This is particularly true of the foothill and lower mountain settings where most forested trust lands can be found. What is known about the prehistoric archaeology of the region is biased toward the lowlands, particularly coastlines, where most development occurs and, therefore, where most archaeological surveys have been conducted. Not all forested trust lands have been intensively surveyed for archaeological resources. The same is true for nearby lands of the National Forests. Most sites in these forests have been found along streams or on high ridges, but this may be due in part to a tendency for land managers to survey what they consider high probability areas more intensively than lower probability slopes.

For a background summary of cultural resources in western Washington, see Appendix D, Section D.7.

4.12.4 Environmental Effects

Timber harvesting can have a severe negative impact on cultural resource sites. Culturally modified trees, if not recognized before harvest, can be cut down and destroyed. Historic equipment may be damaged or moved from its original location, changing its context and association. Archaeological sites, both historic and prehistoric, are likely to be severely damaged by the movement of logging equipment, dragging of logs, and piling of slash into burn piles. Although lithic scatters will not be entirely destroyed and may retain some scientific or cultural value, the relative positions of artifacts and most if not all cultural features, such as hearths, rock alignments, food processing facilities, and remains of dwellings are likely to be disturbed beyond recognition.

Although preharvest archaeological surveys will identify many sites that can be protected by avoidance, surveys do not find 100 percent of all sites, and avoidance can sometimes be incomplete, so impacts can still occur.

Cultural uses of forestlands by Indian tribes can be affected by timber harvests. On the negative side, elimination of old timber stands, or exposing important spirit questing or sacred sites to view by cutting surrounding trees reduces people's ability to use such sites and may eliminate them altogether as components of the living culture. Logging in lowlands eliminates cedar trees, which are the source of basket making and ceremonial materials; culturally important plants that grow in mature forest stands may become less abundant. On the positive side, timber harvesting, like the traditional burning of forests, encourages the growth of berry-producing species and provides forage for game animals. Cedar is also promoted on many forested trust lands by the removal of competing tree species.

4.12.4.1 DNR Cultural Resource Protection Procedures

To avoid adverse impacts on cultural resources, DNR follows procedures derived from Section 106 of the National Historic Preservation Act (U.S.C. 470 et seq.). First, during the field layout or compliance stage or a timber sale, staff identify known sites and areas with high site potential by using DNR's Total Resource Application Cross-Reference System and soliciting input from Native American groups and others with specialized cultural resource knowledge.

Second, lands identified as having a high probability for containing potential cultural resources are subjected to archaeological survey at 25-foot intervals. Cultural resource finds are confirmed, documented with the State Office of Archaeology and Historic Preservation, and, as appropriate, the affected Native American tribe is notified. DNR frequently enters into memoranda of agreement with tribal governments to protect traditional cultural properties and maintain tribal access to resources and localities important to the continued practice of their traditional cultures.

These procedures greatly reduce the probability that timber harvest activities will negatively affect cultural resources. They do not, however, entirely eliminate those effects for two reasons. First, only potential cultural resources and high probability areas are surveyed, leaving sites that might occur in lower probability areas unprotected. Second, archaeological surveys, particularly in forested environments, sometimes are not able to locate existing cultural resources, which lie hidden under vegetation and/or soil. Despite conscientious efforts by DNR staff, some cultural resource sites may be missed by surveys and sites may be damaged by timber harvest practices. However, DNR protection practices reduce the potential of impacts to cultural resources to the point that impacts from all Alternatives are expected to be minor.

4.12.4.2 Approach to Analysis

Although impacts to cultural resources would be minor under all Alternatives, potential effects to resources vary by Alternative. The level of effort needed to protect these resources also varies, and to a greater degree than the anticipated effects.

It is not possible to assess the actual impact each sustainable harvest Alternative would have on cultural resources or the level of effort that would needed to protect these resources. This is because only a fraction of forested trust lands have been surveyed for cultural resources to date. It is also because this is a programmatic analysis, which does not identify specific land parcels for harvest. This analysis is, therefore, qualitative and addresses differing probabilities for encountering and affecting cultural resources based on the frequency of cut and the extent to which stream corridors are affected.

4.12.4.3 Analysis Criteria

The archaeological site records maintained at the Washington Office of Archaeology and Historic Preservation were reviewed to obtain a general impression of the types of prehistoric archaeological sites found in each of the planning units and their environmental settings. That analysis demonstrated that between 90 and 95 percent of documented sites in each area were located within about 400 yards of a stream, river, lake, or body of saltwater (i.e., partially within areas designated in the Habitat Conservation Plan as Wetland Management Zone and Riparian Management Zone).

Sites found near streams include culturally modified cedars, village sites, shell middens, open camps, lithic scatters, rock shelters, cemeteries, and petroglyphs. Rock shelters, quarry sites, huckleberry processing sites, and a few lithic scatters occurred at greater distances from water. Many earlier logging sites, particularly skid roads and large stumps with springboard cuts, are also most likely to be preserved in these settings. Consequently, Alternatives that propose more harvest activity in streamside environments would require a greater level of effort to protect potential cultural resources, and would have a greater probability to affect cultural resources that may be missed by archaeological surveys. They are, therefore, ranked higher in impact and level of effort.

Stands greater than 150 years old are more likely to still contain culturally modified trees, never-disturbed archaeological sites, and huckleberry processing features. Older stands are also more likely to be used by Native American tribes for traditional cultural practices and may need to be addressed in memoranda of agreement with the affected tribes. Alternatives that propose more harvest in old forest stands are, therefore, ranked as having a greater potential to affect cultural resources and to require greater effort to protect these resources.

Harvest frequency is used as a criterion because the more frequently an area is logged, the more damage may occur to archaeological sites that may remain undiscovered following archaeological surveys. Alternatives with higher harvest frequencies are, therefore, ranked as having a higher potential to affect cultural resources.

4.12.4.4 Results of the Analysis, by Alternative

Table 4.12-1 presents the results of analysis of the six sustainable harvest Alternatives according to their potential impact on cultural resources. This may also be read as the relative level of effort that would be required under each Alternative to protect cultural resources using archaeological surveys, site documentation, and consultation and memorandums of agreement developed with Native American tribes.

In Table 4.12.1, columns describing streamside effects, harvest of old forest stands, and harvest frequency provide rationale for the ranking. Impact ranking under each criterion is given in parentheses. Overall rank is an ordering of the total ranks of all three criteria. In making this calculation, the weight of streamside effects is considered to be double that of the other two criteria. The Alternative with the highest rank is expected to have the least potential impact on cultural resources and require the lowest level of effort to protect such resources.

Alternative 5, which has the second-highest level of disturbance of riparian areas, some protection of old forests, and the highest frequency of harvest, is expected to have the greatest potential impact on cultural resources and to require the greatest level of effort to

Table 4.12-1. Ranking of Alternatives According to Their Effect on Cultural Resources[1/]

Alternative	Streamside Effects[2/]	Harvest of Older Stands[3/]	Harvest Frequency	Rank
1	Disturbance at 2 % of area per decade (1)	No additional stipulations (4)	60 yr (2)	1
2	Disturbance at 4 % of area per decade (2)	No additional stipulations (4)	60 yr (2)	3
3	Disturbance at 5% of area per decade (3)	No additional stipulations (4)	60 yr (2)	4
4	Same as 3 (3)	Harvest of >150 year stands deferred (1)	80 yr (1)	1
5	Disturbance at 7 % of area per decade (5)	10 to 15% to be maintained in old forest conditions (2)	40 yr (6)	6
Preferred Alternative	Disturbance at 8% of area per decade (6)	10 to 15% to be maintained in old forest conditions (2)	60 yr (2)	5

Data Source: Evaluations of Alternatives, Section 2.6.
1/ A rank of 1 equals lowest potential for impacts.
2/ Based on Table 4.9-1.
3/ Old forest research areas are deferred and 20 percent of Olympic Experimental State Forest lands are maintained in old forest conditions in all Alternatives.

protect these resources. Alternatives 1 and 4 are expected to have the least potential impact and require the least effort for cultural resource protection. Alternative 4 protects old forests, moderately protects riparian environments, and would have the longest harvest interval. Alternative 1 permits the least disturbance of riparian environments, but has a higher harvest frequency and provides no additional protection for older forests. The

Preferred Alternative would have the second greatest potential impact on cultural resources and thus would require a higher level of effort to protect cultural resources than would Alternatives 1 through 4.

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4.13 RECREATION

4.13.1 Summary of Effects

This section analyzes the potential effects of the Alternatives on recreation. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

Environmental impacts on recreation resources are assessed in relation to harvest level. More intensive harvest would have a larger impact on the landscape, potentially affecting the quality of recreation experiences in adjacent and nearby areas. Potential effects on recreation may be mitigated on a case-by-case basis during operational planning prior to the initiation of harvest activities. Potential effects may be mitigated by employing harvest systems that minimize potential visual effects and by relocating or rerouting affected recreation facilities, particularly trails, as appropriate. All of the Alternatives would meet the requirements of DNR policies and procedures that address recreation and public access (Policies No. 25 and 29). As a result, none of the Alternatives are expected to result in any probable significant adverse environmental impacts to recreation.

The effects of the proposed Alternatives on fish and wildlife could, in turn, affect recreational fishing and hunting on forested trust lands. Fishing and hunting opportunities on forested trust lands could be positively affected to the extent that improvements in habitat and habitat suitability contribute to greater numbers of fish and game populations in some or all of the planning units. The potential effects on fish and wildlife are discussed in more detail in Sections 4.10 and 4.3, respectively.

4.13.2 Affected Environment

Approximately 40 percent of all uplands in the state of Washington are publicly owned, with the federal government managing 12.9 million acres or 28 percent of the state (Interagency Committee for Outdoor Recreation 2002). Statewide, DNR manages about 2.9 million acres of trust lands, with about 1.4 million forested acres located in westside counties. These state trust lands are managed for the support of trust beneficiaries with recreation being a secondary use allowed under the Multiple Use Act (Chapter 79.68 RCW, recodified at Laws of 2003, Ch. 334, sec. 555(2)). The Multiple Use Act allows for recreational use as long as the uses do not damage resources and the use is compatible with trust management responsibilities (Forest Resource Plan Policy No. 29 [DNR 1992a]).

DNR generally provides public access for multiple uses on forested trust lands. There are, however, situations where DNR controls vehicular or other access. Public access may be closed, restricted, or limited to protect public safety; to prevent theft, vandalism, and garbage dumping; to protect soils, water quality, plants, and animals; or meet other Forest Resource Plan or Habitat Conservation Plan (HCP) objectives (Forest Resource Plan Policy No. 25 [DNR 1992b]).

A recent assessment of outdoor recreation in the state of Washington found that residents participated in at least 170 different types of outdoor recreation in 15 major categories (Interagency Committee for Outdoor Recreation 2002). Population growth of about

20 percent over the last decade has resulted in increased numbers of people engaged in recreation, even though the percent of the population actively participating in outdoor recreation declined over this period. More than half of the state's population currently participates in some form of outdoor recreation. Roughly half of outdoor recreation activity in the state is local, with the other half shared between state, federal, and private providers.

Outdoor recreation activities that occur on state lands include walking/hiking, horseback riding, off-road vehicle use, picnicking, camping, hunting, fishing, and more. The Interagency Committee for Outdoor Recreation assessment found that 53 percent of the state's population participated in the walking/hiking recreation category, with 20 percent picnicking, 13 percent camping, 13 percent fishing, 9 percent using off-road vehicles, and 6 percent hunting/shooting (Interagency Committee for Outdoor Recreation 2002).

Participation in all of these activities, with the exception of fishing and hunting/shooting, is projected to increase over the next 20 years. Increases over the next 10 years are expected to range from 5 to 10 percent for camping to 20 percent for picnicking. The numbers of people fishing and hunting/shooting are projected to decrease by 5 percent and 15 percent, respectively, over the same period (Interagency Committee for Outdoor Recreation 2003).

Westside trust lands that receive significant public use include Capitol Forest in Thurston County, Tahuya State Forest in Mason County, Yacolt Burn State Forest in Skamania County, and Tiger Mountain State Forest in King County. Recreation facilities in these locations include campgrounds, picnic areas, hiking trails, off-road vehicle trails, and interpretive facilities (Interagency Committee for Outdoor Recreation 2003, pages 45-46).

The existing DNR road system receives heavy recreation-related use, providing the public with access to specific recreation areas, such as trailheads, campgrounds, and picnic areas. In addition, a large portion of recreational users of trust lands use the road system as the primary focus of their recreational activity—driving the road systems and occasionally dispersing across the landscape to hunt, birdwatch, gather mushrooms or berries, or engage in some other non-facility oriented activity. A recent survey, for example, estimated that approximately 50 percent of back road and "off of road" fuel use in the state of Washington was for uses other than off-road motorized activities (off-road vehicles and snowmobiling) and non-motorized activities (hiking, mountain biking, cross-county skiing, and horseback riding). The other back road and off of road uses that made up about 50 percent of total fuel use included hunting, driving, sightseeing, camping, and fishing (Hebert Research, Inc. 2003).

Statewide, DNR manages about 1,150 miles of recreation trails. Approximately 840 miles or 73 percent of these trails are located on western Washington forested state trust lands, with 347 miles (41 percent of westside total) designated as multiple-use motorized trails. The remaining miles are designated multiple-use, non-motorized (34 percent), hiker only (13 percent), and winter (12 percent) (Table 4.13-1).

Roughly 457 miles of the westside trails (54 percent) are located in the South Puget Sound area, which includes Mason, Pierce, King, and Kitsap Counties and the Tahuya, Green Mountain, Tiger Mountain, and Tahoma State Forests.

DNR also manages some westside lands as Natural Area Preserves and Natural Resource Conservation Areas to protect examples of undisturbed ecosystems, rare plant and animal species, and unique geologic features. These areas, which are off base for harvest, help support trust management objectives by managing and conserving habitat for HCP species, where appropriate.

Natural Area Preserves are generally available only for educational and scientific access. Natural Resource Conservation Areas are available for low impact recreation, such as nature study, walking, and day hiking, as well as for research and education. Mt. Si Natural Resource Conservation Area in King County, for example, is an important hiking destination (Interagency Committee for Outdoor Recreation 2002).

4.13.3 Environmental Effects

Management objectives under the proposed Alternatives could affect recreation use of forested trust lands in three main ways. First, harvest activities could have primarily negative effects on existing recreation activities in and around harvested areas. This is reflected in the public concerns raised during scoping for this project (Appendix A). Concerns were expressed about the integration of forest management and recreation, and the location of harvest units relative to recreation areas.

The linear nature of the trail system suggests that trail use would be the most likely recreation activity to be affected by increased harvest activities. Trails in active harvest areas are likely to be closed, moved, or decommissioned as a result of harvest activities.

Table 4.13-1. DNR Westside Recreation Trails, By Region (in Miles)

	Central	Northwest	Olympic	Southwest	South Puget Sound	Total
Multiple-Use Motorized	87	30	15	17	199	347
Multiple-Use Non-Motorized	80	43	0	60	102	285
Hiker Only	6	41	4	1	57	109
Winter	0	0	0	0	100	100
Total	**173**	**114**	**19**	**78**	**457**	**842**

Source: Personal communication, Lisa Anderson, 2003.

In addition, trails, campgrounds, picnic areas, and some overlook areas could be negatively affected by noise, dust, and traffic generated during logging activities. Higher harvest volumes would likely increase these potential effects.

Second, higher harvest volumes would also result in more logging truck traffic on DNR roads used by the public for recreation purposes, which could potentially affect a large portion of recreation visitors, depending on the Alternative selected. Estimates of logging truck traffic that would be generated are presented by Alternative in Table 4.11-11 and discussed in Section 4.11.4.2, which discusses potential impacts to transportation infrastructure. Total projected annual average truck traffic generated over the next decade (2004 to 2013) ranges from approximately 90,000 truck trips under Alternative 1, about 85 percent of the annual average for 1998 to 2002, to roughly 147,000 truck trips under

Alternative 3, about 1.4 times the 1998 to 2002 annual average. Approximately 141,000 annual average truck trips would be generated under the Preferred Alternative over this period, 1.36 times the 1998 to 2002 average. Third, the impacts of the proposed Alternatives on fish and wildlife could in turn affect recreational fishing and hunting on forested trust lands.

Although, potential effects on recreation are likely to increase with harvest intensity, this is not necessarily a linear relationship. An increase in the amount of harvest would not necessarily result in a commensurate increase in impacts. In other words, doubling the amount of harvest, for example, would not necessarily result in double the impact. More intensive harvest may, however, result in more complex issues. In addition, potential impacts would vary by user group, with more intensive harvest potentially benefiting some recreation user groups, such as road users, while negatively affecting other groups, such as trail users. The potential impacts of more intensive harvest on road users are also likely to vary by location, with some groups potentially benefiting from new road construction, while increased levels of logging truck traffic on existing roads would negatively affect other groups.

The assessment presented in this environmental analysis is programmatic, meaning that it establishes direction and potential harvest levels for broad land areas rather than scheduling activities on specific patches of land. As a result, it is not possible to identify specific tracts of land or recreational facilities that would be affected by the Alternatives. In addition, the model results for the six Alternatives do not provide a precise schedule of where and when harvest would occur under the different Alternatives. Rather, the results for each Alternative represent one of a number of potential paths to achieve the long-term objectives of that Alternative and are used in this analysis for comparison among Alternatives rather than an accurate prediction of the future.

Given these constraints, the following analysis addresses the effects of the Alternatives in terms of the projected amount of land that would be subject to high-volume removal harvest (defined as harvests removing more than 20 thousand board feet per acre in volume) and the projected amount of open forest under each Alternative. This analysis proceeds from the assumption that more intensive harvest would have larger potential effects during harvest in terms of noise, air, and traffic impacts, as well as the resulting post-harvest impact to the landscape.

Projected harvest under the proposed Alternatives is grouped into three harvest types for the purposes of this analysis. These harvest types, referred to as low-volume, medium-volume, and high-volume removal harvest, represent groupings of silvicultural treatments that produce similar ranges of harvest intensity. Low-volume removal harvest (defined as harvests removing less than 11 thousand board feet per acre in volume) includes silvicultural treatments like small wood thinning. Medium-volume removal harvest (defined as harvests removing between 11 and 20 thousand board feet per acre in volume) includes silvicultural treatments such as variable density thinning, hardwood management, and uneven-aged management. High-volume removal harvest (more than 20 thousand board feet per acre volume harvests) includes regeneration harvests with legacy retention, heavier partial harvest, and some variable density thinnings.

The percent of harvest type (low, medium, or high removal volume) acres by decade is presented by Alternative in Section 4.2, Forest Structure and Vegetation. Average annual acres of high-volume removal harvest are presented by Alternative and decade in Figure 4.13-1. These data indicate that high-volume removal harvest from 2004 to 2013 would occur over larger areas under the Preferred Alternative and Alternative 3. High-volume removal harvest would occur over larger areas under Alternative 5 and the Preferred Alternative for the following two decades (2014-2023 and 2024-2033). High-volume harvest over the remaining decades that make up the 64-year planning period is projected to occur over the largest areas under Alternatives 3 and 2 for each decade. High-volume removal harvest would occur over smaller areas under Alternatives 1 and 4 for all of the decades under consideration (Figure 4.13-1).

These projected levels of harvest provide one general indicator of potential recreation impacts, with Alternatives 3 and 5 and the Preferred Alternative likely to have relatively high impacts compared to Alternatives 1 and 4. Viewed at the planning unit level, high-volume harvest would generally occur over smaller areas under Alternatives 1 and 4 for most decades. The Alternatives with the largest areas of high-volume removal harvest tend to vary from unit-to-unit and by decade.

Viewed in terms of total acres harvested, high-volume removal harvest is generally lower in the South Puget and Straits HCP Planning Units than in the other four units (Figure 4.13-2). In addition, the areas of high-volume removal harvest in the Olympic Experimental State Forest unit are relatively small under Alternatives 4 and 1, compared to the other Alternatives. In other words, the relative differences between Alternatives 4 and 1 and the other Alternatives are much larger in the Olympic Experimental State Forest than they are in the other HCP Planning Units (Figure 4.13-2).

In addition to having larger potential effects during harvest in terms of noise, air, and traffic impacts, more intensive harvest would have a larger impact on the landscape potentially affecting the quality of recreation experiences in adjacent and nearby areas. The amount of high-volume removal harvest viewed in acres by decade (discussed above) provides one perspective on these potential effects. A second perspective is provided by considering the projected amount of open forest. Figure 4.4-3 in Section 4.4 (Wildlife) identifies the percent of total forest area in three different forest structure classes (ecosystem initiation forest, competitive exclusion forest, and structurally complex forest) under each Alternative. Alternatives with greater levels of ecosystem initiation forest would result in greater amounts of open forest.

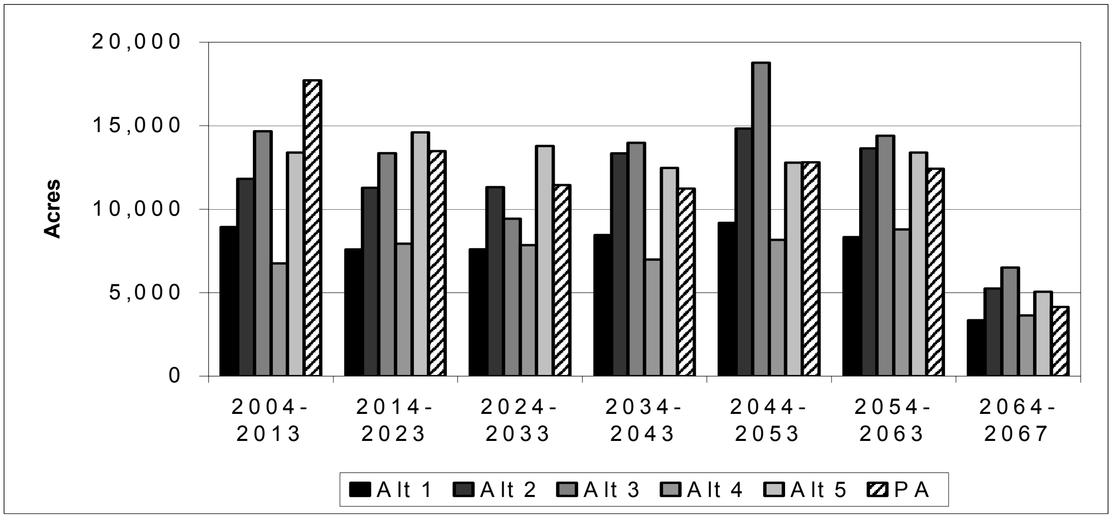

Figure 4.13-1. Average Annual High Volume Removal Harvest Acres, by Alternative and Decade

Notes:

1. High volume removal harvest would likely result in greater than 20 thousand board feet per acre volume harvests.
2. Average annual harvest acres are calculated by dividing total harvest acres per decade by 10 for the six full decades. Average annual acres for 2064 through 2067 were calculated by dividing total acres by 4.

PA = Preferred Alternative

Source: Model output data – timber flow levels.

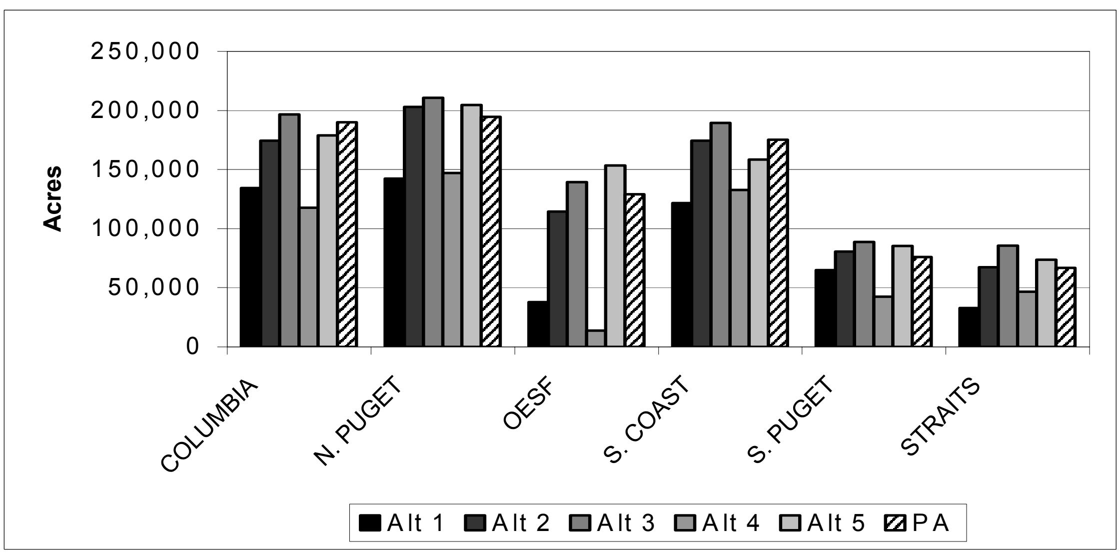

Figure 4.13-2. Total High Volume Removal Harvest Acres by Alternative and HCP Planning Unit

PA = Preferred Alternative

Data Source: Model output data – timber flow levels.

Overall, all six Alternatives would result in similar amounts of ecosystem initiation forest in both the short term and the long term. The amount of ecosystem initiation forest would remain slightly lower in both the short term and the long term under Alternatives 1 and 4 than it would under the other alternatives (Figure 4.4-1). The Preferred Alternative would generate slightly higher levels of this forest type than Alternative 5 in the short term (2013). In the long term (2067), the amount of ecosystem initiation forest would be largest under Alternative 5, followed by the Preferred Alternative and Alternatives 3 and 2, with Alternatives 4 and 1 having the smallest amounts (Figure 4.4-1). This may not, however, hold true within certain planning units in some time periods.

The effects of the proposed Alternatives on fish and wildlife could, in turn, affect recreational fishing and hunting on western Washington forested state trust lands. Fishing and hunting opportunities on forested trust lands could be positively affected to the extent that increased amounts and quality of habitat contribute to greater abundance of fish and game in some or all of the planning units. All six Alternatives would likely result in increases in suitable habitat for deer and elk in the long term. In the short term, all alternatives, except the Preferred Alternative and Alternative 3, would decrease the availability of suitable deer and elk forage. The potential effects on fish and wildlife are discussed in more detail in Sections 4.10 and 4.4, respectively.

Potential effects on recreation may be mitigated on a case-by-case basis during operational planning prior to the initiation of harvest activities. Potential effects may be mitigated by employing harvest systems that minimize potential visual effects and by relocating or rerouting affected recreation facilities, particularly trails, as appropriate. All of the Alternatives would meet the minimum requirements of DNR policies and procedures that address recreation and public access (Policies No. 25 and 29).

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4.14 SCENIC RESOURCES

4.14.1 Summary of Effects

This section analyzes the potential effects of the Alternatives on scenic resources. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

Lands managed for timber production under all Alternatives would be managed under DNR's visual management procedure (PR 14-004-080), which seeks to minimize potential impacts to scenic resources by managing harvest activities with respect to sensitive viewshed areas. Potential visual effects associated with the proposed Alternatives may be mitigated on a case-by-case basis during operational planning prior to the initiation of harvest activities. Operational planning by the DNR includes policies and procedures related to green-up (growing young trees for a specific time before adjacent trees may be cut), reforestation, and harvest unit size that contribute to the management of forested landscapes. As a result, none of the Alternatives are expected to result in any probable significant adverse environmental impacts on scenic resources.

4.14.2 Introduction

This section addresses the potential effects of the proposed Alternatives on scenic resources. Scenic value concerns raised during public scoping for this project included requests that DNR consider impacts to scenic resources, including size and shape of clearcuts and their location relative to highways.

4.14.3 Affected Environment

DNR manages approximately 1.5 million acres of western Washington state trust lands. Approximately 1.4 million acres of these lands are forested. These lands span vegetation zones from near sea level to mountaintops and include a wide range of landscape types and scenic resources characteristic of western Washington, including coastal and high elevation forests, alpine lakes, and rocky shorelines. High-quality scenery, especially scenery with natural-appearing landscapes, is generally regarded as an important resource that enhances peoples' quality of life and influences the quality of recreation experiences and, in some cases, adjacent property values.

Although DNR primarily manages trust lands to produce income for the various trusts and maintain a healthy ecosystem, visual concerns are also considered. Visual concerns do not, however, apply to all areas. Areas where potential visual concerns exist include major highway corridors, cities and towns, adjacent housing developments, and trails and other recreation areas. DNR's visual management procedure (PR 14-004-080) outlines the guidelines whereby DNR regions locate areas that may be managed to reduce the visual impact of harvest and road-building activities. In cases where visual concerns do apply, management decisions seek a balanced solution among visual impact, income, and ecosystem objectives.

In addition to forested trust lands that are managed for the support of trust beneficiaries, DNR also manages some state trust lands as Natural Area Preserves (26,400 acres) and Natural Resource Conservation Areas (80,500 acres). These lands are managed to preserve the best remaining examples of many ecological communities and to protect outstanding native ecosystems; habitat for endangered, threatened, and sensitive plants and animals; and scenic landscapes. These lands, which are off base for harvest, help support management objectives by managing and conserving habitat for wildlife, where appropriate.

4.14.4 Environmental Effects

The sustainable harvest calculation does not include site-specific harvest plans that can be evaluated for their scenic impacts. Alternatives may, however, include different patterns of harvest at a landscape level. These potential effects are considered in the following paragraphs. Model results for the six Alternatives are not a prediction of where and when harvest would occur under the different Alternatives. Rather, the outputs for each Alternative represent one of a number of potential paths to achieve the long-term objectives of that Alternative.The outputs are also used in this analysis for comparison among Alternatives rather than an accurate prediction of the future. Given these constraints, the following analysis addresses the effects of the potential Alternatives in terms of the projected amount of land that would be subject to more intensive harvest and the projected amount of open forest under each Alternative. Potential negative effects on scenic resources are assumed to increase with harvest intensity.

Projected harvest under the proposed Alternatives is grouped into three harvest types (low-volume, medium-volume, and high-volume removal harvest) for the purposes of analysis. The percent of harvest type acres by decade is presented by Alternative in Section 4.2, Forest Structure and Vegetation. Average annual high-volume removal harvest acres are presented by Alternative and decade in Figure 4.13-1.

These data indicate that high-volume removal harvest from 2004 to 2013 would occur over larger areas under the Preferred Alternative and Alternative 3. High-volume removal harvest would occur over larger areas under Alternative 5 and the Preferred Alternative for the following two decades (2014-2023 and 2024-2033). It is important to note that much of the high-volume harvest under the Preferred Alternative would be heavy thinning, which would have little or no affect on scenic resources. High-volume harvest over the remaining decades that make up the 64-year planning period is projected to occur over the largest areas under Alternatives 3 and 2 for each decade. High-volume removal harvest would occur over smaller areas under Alternatives 1 and 4 for all of the decades under consideration (Figure 4.13-1).

A second perspective is provided by considering the projected amount of open forest. Figure 4.4-3 in Section 4.4 (Wildlife) identifies the percent of total forest area in three groups of forest structure classes (ecosystem initiation forest, competitive exclusion forest, and structurally complex forest) under each Alternative. Alternatives with greater levels of ecosystem initiation forest would result in greater amounts of open forest.

Overall, all six Alternatives would result in similar amounts of ecosystem initiation forest in both the short term and the long term. The amount of ecosystem initiation forest would remain slightly lower in both the short term and the long term under Alternatives 1 and 4 than it would under the other Alternatives (Figure 4.4-1). The Preferred Alternative would generate slightly higher levels of this forest type than Alternative 5 in the short term (2013). In the long term (2067), the amount of ecosystem initiation forest would be largest under Alternative 5, followed by the Preferred Alternative and Alternatives 3 and 2, with Alternatives 4 and 1 having the smallest amounts (Figure 4.4-3). This may not, however, hold true within certain planning units in some time periods.

These broad landscape-level measures provide some indication of the Alternatives that would have a higher potential to affect scenic quality based on the intensity of timber harvest, with Alternatives 5 and 3 and the Preferred Alternative involving more high-volume removal harvest and resulting in larger amounts of open forest. However, lands managed for timber production under all Alternatives would be managed under DNR's visual management procedure (PR 14-004-080), which seeks to minimize potential impacts to scenic quality by managing harvest activities with respect to sensitive viewshed areas.

Potential visual effects associated with the proposed Alternatives may be mitigated on a case-by-case basis during operational planning prior to the initiation of harvest activities. Operational planning by DNR includes policies and procedures related to green-up, reforestation, and harvest unit size that contribute to the management of forested landscapes.

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Chapter 4

4.15 CUMULATIVE EFFECTS

4.15.1 Summary

This section analyses cumulative effects. Cumulative effects are defined under both a broad and narrow definition for this analysis. DNR recognizes that cumulative effects conditions are occurring and have the potential to occur in the future in watersheds where DNR manages western Washington forested trust lands. The analysis examines current forest conditions, wildlife habitats, fish, water resources, and potential impacts of future harvests. DNR's policies and procedures are in place and implemented to manage and reduce the risk of cumulative effects occurring. The Alternatives with higher levels of activities in the first decade, Alternative 5 and the Preferred Alternative, have a somewhat higher risk of contributing to cumulative effects, especially related to water resources. However, all Alternatives implement various mitigation measures for cumulative effects to forest vegetation, wildlife and water resources. These measures include, but are not limited to, implementation of the Habitat Conservation Plan (HCP) Riparian Management Zones, procedure for management of potential slope instability, visual area management, procedure for adjacency of regeneration harvest units, and leave trees strategy. The expectation is that the overall level of cumulative effects would be reduced under all Alternatives in the future due to the Board forest management policies, DNR's HCP and operational procedures in combination with Forest Practices Rules, the Northwest Forest Plan, and other regional programs, such salmon recovery efforts (Salmon Recovery Funding Resource Board), HCPs developed by private forestry companies (e.g., Plum Creek, Port Blakely, Simpson Timber, West Fork Timber), and utility companies (e.g., City of Seattle, Tacoma Water). These programs should reduce the potential for future cumulative effects by requiring that landowners do their share of mitigation and avoidance. All of the proposed Alternatives would be expected to provide effective mechanisms in policy and procedures to provide mitigation against cumulative effects where DNR manages a portion of the landscape.

4.15.2 Introduction

Cumulative effects are not defined in the Washington State Environmental Policy Act. Here cumulative effects are analyzed using a combination of approaches that consider "other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other action" (National Environmental Policy Act, 40 C.F.R. § 1508.7) and with a narrower definition of "changes to the environment caused by the interaction of natural ecosystem processes with the effects of two or more forest practices" (Forest Practices Rules, Washington Administrative Code 222-12-046). Because forest management activities are regulated under the Forest Practices Act, this definition is useful for purposes of this sustainable harvest calculation. Cumulative effects can result from multiple forest practices conducted over the same time period but dispersed spatially, or from multiple forest practices that are conducted at the same site over time.

The measures used to assess the impacts of cumulative forest practices in this analysis are forest conditions (existing and changes to forest stand development stages and age-classes) and disturbances (in particular, regeneration harvest rates).

This section provides descriptions of current conditions for forest vegetation, wildlife, riparian habitat, fish, hydrology, and water quality within watersheds where there are western Washington forested trust lands. The analysis then focuses in on a select group of watersheds and examines the relative differences among the Alternatives in the regeneration harvest rates within selected watersheds. This section concludes with a summary of the analysis and describes how the forest management policies employed in the Preferred Alternative help to mitigate for potentially significant adverse cumulative effects.

4.15.2.1 Analysis Approach

Landscapes in western Washington are characterized by a multitude of land uses, including forest, urban, suburban, and agricultural. The amount and nature of forests in any landscape is highly variable. Within those areas that are forested, there is a wide range of forest types and conditions with various types of forest structures. The distribution of forest structures over time and space is a reasonable basis for assessing the potential cumulative effects in the forest environment. It is beyond the scope of this non-project Final EIS to characterize precisely all the conditions and land uses. Land uses such as urban, suburban, or agricultural are extremely variable in their environmental effects. The analysis of environmental effects on these land uses would require very site-specific information (e.g., the type of farming practiced and the number of dwellings per acre in a subdivision).

The Alternatives represent different sets of policies and procedures that direct the management strategies applied to the land base. However, the Alternatives also all have in common strategies designed to manage the effects on specific resources. This analysis attempts to characterize how different suites of policies and procedures interact over time and space. All Alternatives are expected to result in changes in forest structure that should result in more structurally complex forests over time.

This cumulative effects analysis uses a semi-quantitative approach that ranks watersheds for several key resource areas. The analysis also examines and extends the impact analysis of multiple harvest activities at the watershed level from the Forest Structure and Vegetation section (Chapter 4, Section 4.2). The term *watershed* represents the Washington State Department of Ecology watershed administrative units (WAU) per March 2002 delineations.

This analysis is a screening tool for discerning the potential for proposed changes in policies and procedures governing forest management activities on forested trust lands to result in adverse cumulative effects on fish, hydrology, water quality, soils, and wildlife. While this analysis does not provide precise site-specific conclusions about the current or future existence of cumulative effects, it does provide information on what types of cumulative effects might occur and *where* these effects would most likely occur. This approach is based on reasonably available information and avoids speculative conclusions.

In this way, information contained in this analysis indicates where additional site-specific analyses in project-level planning may be appropriate.

This cumulative effect analysis evaluates the impacts of the Alternatives on both trust and, in a limited sense, non-trust forest lands. For example, many effects to riparian system may not occur at the point of disturbance but may result in downstream effects. Therefore, assessment of current conditions for a resource was done by examining data at the watershed scale and across ownerships. Several datasets were used in this analysis. Geographic Information System data, in combination with assumptions about activities on private, state, and federal forested lands, were used to examine the disturbance/condition level of both watersheds and five Westside Habitat Conservation Plan HCP Planning Units, as well as the risk that DNR management activities may contribute to significant adverse cumulative effects. Assumptions about activities (such as rotation length and stream buffers) on private and federal forestland were based upon management strategies (HCPs and the Northwest Forest Plan) and state law, including the Forest Practices Rules. The risk of adverse cumulative effects was based on the type of management and the degree of management intensity proposed under each Alternative. For example, watersheds with greater amounts of hydrologically immature forest would likely require more careful tactical and operational-level planning and analysis under Alternatives 3, 5, and the Preferred Alternative than under Alternatives 1 and 4, because more frequent harvest activities are anticipated under Alternatives 3, 5, and the Preferred Alternative. However, if most of the land in one of these watersheds is federal, harvest levels, and, therefore, the risk of adverse cumulative effects, are likely to be much lower than if most of the watershed is privately owned.

Although the screening tool does not provide precise site-specific conclusions about the current or future existence of cumulative effects, available evidence and literature (e.g. Northwest Forest Plan, Endangered Species Act listings, Clean Water Act 303(d) listings, watershed analyses) suggest that cumulative effects are occurring at some locations (watersheds/river basins) throughout each of the HCP Planning Unit areas. However, the programmatic nature of this non-project action (Board policy decisions), the scale of the analysis (1.4 million of western Washington forested trust lands), and limitations of the available landscape-level data suggests to DNR that site-specific cumulative effects determinations are not possible, and could not be accurately determined for this Final Environmental Impact Statement.

For each resource area, watersheds are ranked into quartiles (upper, upper mid, lower mid and lower) according to current conditions (see Appendix E for examples). Current conditions are represented with the best reasonably available data and information. The upper quartile is used to discern the highest relative potential for adverse cumulative effects; the rating is “highest” in a relative sense, not having any absolute or quantitative significance. Ranking a watershed in the upper quartile does not indicate that adverse cumulative effects are occurring or will occur. The upper quartile represents only a screening tool to assist in identifying the current condition of resources in specific watersheds that may be more vulnerable to potential cumulative effects.

Model outputs provide a quantitative approach for assessing how well each Alternative is likely to achieve the Board's goals. Each Alternative was analyzed over all the landscapes and over multi-decade periods. The purpose was to see how the forests and associated habitats changed over time and space. The modeling analysis demonstrated that harvest rates vary by Alternative; therefore, potential cumulative effects are likely to vary within the various resource areas and across landscape over time.

4.15.2.2 Data Sources

Geographic Information System data were used to estimate current conditions across the landscape. This information was used to estimate where current conditions or levels of disturbance potentially place a watershed at higher risk for cumulative effects over the planning period. For example, high resource sensitivity may be identified for a variety of reasons, including, but not limited to, the presence of important and sensitive resources (e.g., bull trout), significant loss or significant disturbance of rare or uncommon habitats (e.g., old forest), or the presence of potentially triggering characteristics (e.g., unstable slopes or sensitive soils) that may materially affect a significant resource.

Vegetation data for this analysis were derived from both DNR sustainable harvest model and the Interagency Vegetation Mapping Project (2002). The primary purpose of the Interagency Vegetation Mapping Project maps is to serve as monitoring tools for the Northwest Forest Plan, which provides management direction for the USDA Forest Service and the USDI Bureau of Land Management. The Interagency Vegetation Mapping Project maps show existing vegetation, canopy cover, size, and cover type for the entire range of the northern spotted owl using satellite imagery from the Landsat Thematic Mapper. The Interagency Vegetation Mapping Project used a regression modeling approach to predict vegetation characteristics from the Landsat data.

Interagency Vegetation Mapping Project data do not identify stand development stages, but the data can be grouped based on tree size classes and percentage of conifer cover. Tree size classes were calculated using quadratic mean diameter, defined as the diameter at breast height of a tree of average basal area for the stand. Quadratic mean diameter was calculated in inches and was based on dominant and co-dominant trees only. The size class models were applied only to areas that met the minimum condition of at least 70 percent total vegetation cover and at least 30 percent conifer cover. Areas that did not meet these two criteria (and thus were not assigned size class values) account for approximately 30 percent of the total area identified as forest vegetation. Size classes (in inches) were grouped as follows: 0 to10, 10 to 20, 20 to 30, and greater than 30. The Interagency Vegetation Mapping Project also identified total green vegetation cover, which includes trees, shrubs, and herbaceous plants. Areas with greater than 30 percent conifer cover were grouped into two classes: less than 70 percent, and 70 percent or more conifer cover.

4.15.2.3 Scale of Analysis

Cumulative effects are discussed at the HCP Planning Unit level. References to the distribution of impacts among watersheds are made, as needed, to explain conditions within a HCP Planning Unit and their component watersheds. Tables summarizing conditions at the watershed level are presented in Appendix E. The analysis focuses on two sets of watersheds: 179 watersheds in which DNR manages at least 5 percent of the watershed, and a subset of these (83 watersheds) in which DNR manages at least 22 percent of the watershed.

4.15.3 Forest Conditions and Wildlife Habitats

This section describes the current forest structure, vegetation, and wildlife habitat conditions in the watersheds where DNR manages western Washington forested trust lands. This section also identifies areas where timber harvest on forested trust lands may appreciably influence the availability of particular wildlife habitats and the species that may be associated with them. As such, some of the tables and discussions below identify areas where certain habitat types represent a small proportion of the total area and where forested trust lands contain a relatively large proportion of the total habitat that exists. In these areas, timber harvest on forested trust lands may carry the risk of reducing the availability of a particular habitat type. Other tables focus on areas where DNR management decisions may contribute to a sizeable increase in the distribution of one habitat type at the expense of others or where DNR timber harvest may provide opportunities to increase habitat diversity in areas dominated by a single habitat type. Analyses in this section are based on three Appendix E tables that list the 179 westside watersheds in which forested trust lands make up at least 5 percent of the total land area. Each of these tables (Appendix E, Tables E-17, E-18, and E-19) identifies the proportion of forested lands in each watershed consisting of a different forested habitat type, and the distribution of that habitat type among different land ownerships. A fourth appendix table, Table E-20, identifies the proportion of each watershed under DNR, federal, private, or other ownership.

The discussions below focus on three forest condition classes (small/open forests, forests with medium/large trees, and forests with very large trees) and one nonforested habitat type (wetlands). Wildlife species associated with the different forest habitat types are discussed in Section 4.4. Although the timber harvest activities addressed in this Environmental Impact Statement are not likely to affect the amount and distribution of a nonforested habitat such as wetlands, habitat quality may be adversely affected by equipment and activities associated with timber harvest (see Section 4.9). Significant regulatory (Forest Practices Act and Rules: RCW 76.09 and WAC 222) and HCP protections exist for wetlands, both forested and non-forested, suggesting that the likelihood of significant impacts to these important habitats is low.

Interagency Vegetation Mapping Project data were used to identify three broad classes of forested vegetation, which roughly approximate the forest habitat types used in other analyses in this Environmental Impact Statement. The small/open forests are most similar to early stages in the stand development, i.e., ecosystem initiation (Table 4.2-4). The "medium-to-large diameter, closed forests" approximate the competitive exclusion stages described in Table 4.2-4, and the "forest with very large trees" are most similar to the structurally complex forest stand development stages (represented by developed understory through old natural forests in Table 4.2-4). Note, however, that the classes in this cumulative effects analysis are defined using different criteria, and are based on a different set of data than the forest structure classes identified in Sections 4.2 and 4.4. Table 4.15-1 lists the criteria used to define the forest structure classes used in this analysis.

The analysis of potential adverse cumulative effects to wildlife species associated with different forest condition classes examines the proportion of the forested area in each watershed comprising each forest condition class. For this analysis, the area identified by Interagency Vegetation Mapping Project data as vegetated areas (excluding agricultural areas) is taken to represent forested areas. As noted above, available data on canopy cover do not distinguish among coniferous, deciduous, shrubby, and herbaceous vegetation, so this analysis likely overestimates the amount of forested habitat in some areas. Also, size class data could be assigned only to areas with at least 70 percent total vegetation cover and at least 30 percent conifer cover. Forest condition class definitions are based on size classes, so areas that do not meet these criteria did not fall into any of the three forest condition classes. This may lead to some underestimation of the amount of forest in the small/open condition, because some recently harvested areas likely have less than 70 percent total vegetation cover and less than 30 percent conifer cover.

4.15.3.1 Current Small/Open Forest

Of the 179 watersheds addressed in this analysis, more than half (107) have between 10 percent and 20 percent of their forested area in small/open forest (Table 4.15-2). Only four watersheds have more than 30 percent small/open forest, and 39 have between 20 and30 percent. Twenty-nine have less than 10 percent of their watershed area in small/open forest. The South Puget Planning Unit has the highest average percentage of this forest condition per watershed, and the Olympic Experimental State Forest has the lowest.

Table 4.15-1. Definitions of Forest Structure Classes Used in this Cumulative Effects Analysis Based on Interagency Vegetation Mapping Project Data

Forest Condition Class	Interagency Vegetation Mapping Project Data Criteria
Forest with small-diameter trees, open forest	Conifer cover[1/] less than 70 percent and quadratic mean diameter less than 10 inches.
Forest with medium- to large-diameter trees, closed forest	All stands with a quadratic mean diameter between 10 and 30 inches, plus stands with conifer cover greater than 70 percent and quadratic mean diameter less than 10 inches.
Forest with very large-diameter trees	All stands with a quadratic mean diameter greater than or equal to 30 inches.

[1/] As defined in Interagency Vegetation Mapping Project data documentation (2002)

Table 4.15-2. Number of Watersheds[1/] With Small/Open Condition Forest by Habitat Conservation Plan Planning Unit

Percent Small/ Open Condition	Columbia	N. Puget	OESF	S. Coast	S. Puget	Straits	Total
<10%	3	10	7	5	0	4	29
10-20%	21	39	15	16	6	10	107
20-30%	12	11	1	3	8	4	39
30-40%	2	1	0	0	1	0	4
Total	**38**	**61**	**23**	**24**	**15**	**18**	**179**
Average[2/]	*19.1%*	*15.6%*	*13.2%*	*15.2%*	*21.9%*	*16.1%*	*16.6%*

Data Source: Cumulative effects forest structure data.
OESF = Olympic Experimental State Forest
[1/] The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations.
[2/] Average = average percentage forested area in small/open condition

Of the 22 watersheds with the highest proportion of small/open forest, 7 are in the Columbia HCP Planning Unit, 6 are in North Puget, 6 are in South Puget, and 3 are in the Straits. None of the these 22 watersheds are in the South Coast HCP Planning Unit or the

Olympic Experimental State Forest. The great majority of small/open forest in these watersheds occurs on private lands. See Appendix E, Table E-17 for the percentage of forested area consisting of small/open forest in all 179 watersheds and the distribution of that habitat among different ownership categories.

Table 4.15-3 summarizes the distribution of habitat among ownerships in 26 watersheds that have a combination of a relatively high proportion of small/open forest (greater than 20 percent) and a large percentage (greater than 90 percent) of the total land area in either

Table 4.15-3. Percent of Small/Open Forest and Ownership in Watersheds[1/] with the Highest Future Potential to Become Dominated by Small/Open Forest[2/]

HCP Planning Unit	Number of Watersheds	Average Percent Small/ Open Forest	Average Percent of Watershed Area in Each Ownership			
			DNR	Federal	Private	Other
Columbia	6	25%	9%	0%	88%	3%
N. Puget	8	25%	20%	0%	79%	1%
OESF	1	21%	26%	4%	67%	2%
S. Coast	3	21%	40%	0%	59%	1%
S. Puget	5	23%	48%	0%	47%	5%
Straits	3	26%	27%	0%	71%	2%
Westside	***26***	***24%***	***26%***	***0%***	***71%***	***2%***

Data Source: Cumulative effects forest structure data
OESF = Olympic Experimental State Forest HCP = Habitat Conservation Plan
[1/] The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations.
[2/] Potential for domination by small/open condition forest based on the current percent of this forest condition and likely management based on ownership in a given watershed.

private or DNR ownership. The more extensive forest management activities on forested trust lands, as are projected to occur under Alternatives 5, 3, and the Preferred Alternative and to a lesser extent under Alternative 2, combined with similar activities on private lands, may result in a situation where more than 50 percent of the area of these watersheds supports small/open forest. Such a large increase in this habitat type may provide temporary benefits to some wildlife species (e.g., foraging habitat for deer and elk, or breeding habitat for certain birds), but may reduce the availability of other forest types, limiting the habitat for species that rely on other habitat types. The more intensive management in these watersheds under Alternatives 5, 3, and the Preferred Alternative may carry greater relative risk to species that rely on interconnected areas of closed-canopy forest. However, of the three Alternatives mentioned (5, 3, and the Preferred Alternative), the forest management strategies of the Preferred Alternative indicate greater increases in more structurally complex forests over the long term than Alternative 1 (No Action). These increases in larger diameter and more structurally complex forest may mitigate for the potential loss of interconnected closed canopy-forest.

Table 4.15-4 portrays the opposite scenario to Table 4.15-3. It summarizes 20 watersheds in which 10 percent or less of the forested area consists of small/open forest. In addition, less than 30 percent of the total land area is in private ownership, that is, DNR and/or the federal government are the dominant landholders in these watersheds. Over time, passive management of forested trust lands (such as is projected to occur in many areas under Alternatives 1 and 4), combined with passive management of federal lands, would result in declines in the amount of small/open forest in these areas. Conversely, more relatively intensive timber harvest on forested trust lands (for instance, under Alternatives 5, 3, 2, or the Preferred Alternative) may provide appreciable increases in the amount of this habitat type. Table 4.15-4 identifies potential opportunities for DNR to ensure that small/open forest continues to be available in all westside watersheds with an appreciable amount of forested trust lands. Abundant shrubby and herbaceous vegetation in such areas would provide foraging habitat for deer and elk, and support an abundant and diverse assemblage of birds (Carey et al. 1996).

Table 4.15-4. Watersheds[1/] Where Management of Forested Trust Lands May Play a Major Role in the Maintenance of Small/Open Forest

HCP Planning Unit	Number of Watersheds	Average Percent Small/Open Forest	Average Percent of Watershed Area in Each Ownership			
			DNR	Federal	Private	Other
Columbia	2	8%	25%	73%	2%	0%
N. Puget	9	7%	26%	54%	17%	3%
OESF	5	8%	23%	47%	27%	2%
Straits	4	7%	24%	54%	20%	2%
Westside	***20***	***7%***	***25%***	***54%***	***19%***	***2%***

Data Source: Cumulative effects forest structure data
OESF = Olympic Experimental State Forest HCP = Habitat Conservation Plan
[1/] The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations.

4.15.3.2 Current Forests with Medium/Large Trees

Nearly three-quarters of the 179 watersheds have at least 40 percent forested land in the forests with medium/large trees (Table 4.15-5).

Table 4.15-6 summarizes the ownership distribution of forests with medium/large trees in the top 25 percent of the watersheds with the highest proportion of forests with medium/large trees. The upper quartile was chosen because this forest condition has the least benefit to a broad range of wildlife species groups (see Section 4.4) and indicates potential forest health impacts (Section 4.2.6). See Appendix E, Table E-18 for the percentage of the forested area with medium/large trees in all 179 watersheds, and the distribution of this forest condition among different ownership categories.

Overall, the average proportion of forested land with medium/large trees on forested trust lands equals the average proportion on private lands. In three HCP Planning Units (North Puget, South Puget, and Straits) the average proportion on forested trust lands exceeds that on private lands. This pattern differs from the ownership pattern for watersheds with high proportions of small/open forest (where private lands are generally the dominant ownership) and forests with very large trees (where federal lands are most common and DNR has the highest proportion of ownership in only 2 of the top 20).

In all of the watersheds with a high proportion of forests with medium/large trees, active forest management may increase habitat diversity within stands and across the landscape. Forests with medium/large trees generally have low levels of structural (and thus wildlife) habitat diversity, and nowhere is this structure class at risk of disappearing from the landscape. All the Alternatives, including Alternative 1 (No Action), project a decrease in the competitive exclusion forest condition on western Washington forested state trust lands. Commercial thinning (as under Alternative 5) may provide temporary benefits to species associated with forest in the small/open condition. Thinning prescriptions designed to enhance structural diversity (as under the Preferred Alternative) may accelerate the

Table 4.15-5. Number of Watersheds[1/] Supporting Various Proportions of Forests with Medium/Large Trees Among HCP Planning Units

	Columbia	N. Puget	OESF	S. Coast	S. Puget	Straits	Total
<20%	2	0	0	0	0	0	**2**
20-40%	9	16	2	9	3	9	**48**
40-60%	23	41	18	11	7	8	**108**
60-80%	4	3	3	4	5	1	**20**
80-100%	0	1	0	0	0	0	**1**
Total	**38**	**61**	**23**	**24**	**15**	**18**	**179**
Average[2/]	*44%*	*45%*	*51%*	*49%*	*49%*	*42%*	***46%***

Data Source: Cumulative effects forest structure data.
OESF = Olympic Experimental State Forest
[1/] The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations.
[2/] Average = average percentage area of medium/large condition forest by HCP Planning Unit.

Table 4.15-6. Summary of Watersheds[1/] Supporting the Highest Proportion of Forests with Medium/Large Trees, and the Proportion of the Watershed in Each Ownership Class

HCP Planning Unit	Number of Watersheds	Average Percent of Forest with Medium/Large Trees	Average Percent of Forest with Medium/Large Trees in Different Ownerships			
			DNR	Federal	Private	Other
Columbia	9	60%	38%	20%	41%	1%
N. Puget	11	62%	35%	28%	33%	5%
OESF	9	59%	32%	16%	46%	7%
S. Coast	8	64%	42%	0%	52%	6%
S. Puget	6	62%	54%	8%	20%	18%
Straits	1	60%	69%	8%	22%	0%
Westside	***44***	***61%***	***39%***	***16%***	***39%***	***6%***

Data Source: Cumulative effects forest structure data
OESF = Olympic Experimental State Forest
HCP = Habitat Conservation Plan
[1/] The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations.

development of more complex forest structures, providing benefits to wildlife species associated with the latter condition. Alternatives with more passive or traditional silvicultural management approaches, (as under Alternatives 1 and 4 for passive approaches and 2, 3, and 5 for more traditional silvicultural management) are more likely to perpetuate single story stands that have less structural diversity.

4.15.3.3 Current Forest with Very Large Trees

Throughout the 179 watersheds addressed in this analysis, forest with very large trees is the least common of the three forest condition classes. Only three watersheds have more than 30 percent of their forested area in forest with very large trees (Table 4.15-7). Nearly two-thirds (118) have less than 5 percent forest with very large trees. Fifty-five of these have less than 1 percent of forest with very large trees. This type of forest does not constitute a majority of the forested habitat in any of the watersheds, nor does it anywhere exceed the amount of either of the other two forest condition classes in any watershed.

Currently, forest with very large trees is not evenly distributed among the five Westside HCP Planning Units and the Olympic Experimental State Forest. Two HCP Planning Units (South Coast and South Puget) have no watersheds with more than 5 percent forest with very large trees (Table 4.15-7). This habitat type is particularly scarce in the South Coast HCP Planning Unit, where 22 of 24 watersheds have less than 1 percent forest with very large trees. In contrast, more than half (10 of 18) of the watersheds in the Straits HCP Planning Unit have at least 5 percent forest with very large trees. The North Puget HCP Planning Unit has the most watersheds with at least 10 percent forest with very large trees (20), while the Olympic Experimental State Forest has the highest percentage of forest with very large trees among all watersheds. In 15 of the top 20 forested trust lands, more

Table 4.15-7. Number of Watersheds[1/] Supporting Various Proportions of Forest with Very Large Trees among HCP Planning Units

Percent of Forest with Very Large Trees	Columbia	N. Puget	OESF	S. Coast	S. Puget	Straits	Total
<1%	14	15		22	4		55
1-5%	13	17	12	2	11	8	63
5-10%	8	9	6			7	30
10-20%	3	12	3			1	19
20-30%		6	1			2	9
>30%		2	1				3
Total	**38**	**61**	**23**	**24**	**15**	**18**	**179**
Average[2/]	*3.4%*	*7.9%*	*8.0%*	*0.4%*	*2.0%*	*7.1%*	*5.3%*

Data Source: Cumulative effects forest structure data
OESF = Olympic Experimental State Forest
1/ The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations.
2/ Average = average percent of forested area with very large trees.

than 10 percent have been designated as Nesting, Roosting, and Foraging Management Areas for northern spotted owls. See Appendix E, Table E-19 for the percentage of the forested area with very large trees in all 179 watersheds, and the distribution of this habitat among different ownership categories. DNR designated northern spotted owl management areas (Nesting, Roosting, and Foraging Management Areas) account for more than 10 percent of forested trust lands in 37 of the 179 watersheds. In most of these, the majority of forest with very large trees falls on federal lands. The 13 watersheds summarized in Table 4.15-8 have less than half of the existing forest with very large trees occurring on federal lands, with the majority of the existing forest being on forested trust lands. In all Alternatives, the area of structurally complex forest on DNR-managed forested trust lands is projected to increase in designated Nesting, Roosting, and Foraging Management Areas (see Table 4.4.3).

Table 4.15-8. Summary of Watersheds[1/] in which at Least 10 Percent of Forested Trust Lands are Designated Northern Spotted Owl Nesting, Roosting, and Foraging Management Areas, and where less than 50 Percent of Existing Forest with Very Large Trees Falls on Federal Lands

HCP Planning Unit	Number of Watersheds	Average Percent of Forest with Very Large Trees	Average Percent of Forest with Very Large Trees in Different Ownerships			
			DNR	Federal	Private	Other
Columbia[2/]	2	4%	30%	14%	41%	15%
N. Puget	11	8%	45%	22%	31%	2%
Westside	***13***	***8%***	***43%***	***21%***	***32%***	***4%***

Data Source: Cumulative effects forest structure data.
1/ The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations.
2/ In one of these watersheds (Hamilton Creek - 280106), 27 percent of the existing very large forest occurs in Beacon Rock State Park, and is thus not likely to be harvested

As noted above, in most of the watersheds with the highest proportion of forest with very large trees, the majority of that habitat occurs on federal lands. Table 4.15-9 summarizes the distribution of habitat among different ownerships in 11 watersheds where at least 10 percent of the forested area consists of forest with very large trees, and where at least 20 percent of that habitat is on forested trust lands. In the short term (i.e., before additional habitat can develop on federal or forested trust lands), relatively more intensive timber harvest on forested trust lands (as under Alternative 5) in these watersheds could substantially reduce the amount and quality of habitat in forest with very large trees in some areas where this type of forest is comparatively plentiful. If Alternative 5 where implemented, more in-depth planning and protection of existing forest stands with very large trees would be warranted.

Fifty-five westside watersheds support little or no forest with very large trees (less than 1 percent of the unit). Intensive harvest of lands in any ownership might carry the risk of effectively eliminating this habitat type—and the species that depend on it—from those watersheds in the foreseeable future (Appendix E, Table E-19), except in areas where such habitats occur on land protected for other policy reasons such as riparian habitat or slope stability. DNR's process of evaluating such effects on the environment during the design of timber harvest projects with an extended State Individual Environmental Protection Act checklist provides an opportunity to redesign or modify the project and reduces the risk of the eliminating the very large tree habitat type. Modification or redesign of a timber harvest project would take into consideration the DNR's policies and procedures, such as but not limited to, leave tree requirements, management for protection of slope stability, Riparian Management Zones, and adjacency of regeneration harvests (Forest Resource Plan Policy No. 32). Varying amounts of older age classes occur in riparian areas, where they routinely receive protection by the Forest Practices Rules and the HCP.

Over the long term, all Alternatives would maintain or increase the total area of structurally complex forests on western Washington forested state trust lands (see Figure 2.6-4 in Chapter 2). For the short term, Alternatives 5 and the Preferred Alternative

Table 4.15-9. Summary of Watersheds[1/] in which at Least 10 Percent of Forested Lands Supports Forest with Very Large Trees, and Where at Least 20 Percent of Existing Forest with Very Large Trees Occurs on Forested Trust Lands

Planning Unit	Number of Watersheds	Average Percent of Forest with Very Large Trees	Average Percent of Forest with Very Large Trees in Different Ownerships			
			DNR	Federal	Private	Other
Columbia	2	13%	38%	56%	7%	0%
N. Puget	7	15%	50%	38%	10%	2%
OESF	2	13%	64%	35%	0%	1%
Westside	***11***	***14%***	***50%***	***41%***	***8%***	***1%***

Data Source: Cumulative effects forest structure data
OESF = Olympic Experimental State Forest
[1/] The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations

provide direction to the DNR to establish a target of 10 to15 percent of each Westside HCP Planning Unit area to be in older forest conditions, while Alternative 4 provides direction to protect from harvest all forest stands managed by DNR that are 150 years and older in 2004.

Current Wetlands

Interagency Vegetation Mapping Project data do not identify all wetland areas. Wetlands are identified in fewer than half of the 179 watersheds addressed in this analysis, and they account for no more than 1.2 percent of the area of any single watershed. These are the best available data for an analysis of this scale, and serve as a screening tool for identifying areas where wetlands may be of particular concern.

Table 4.15-10 assesses watersheds where wetlands may face a higher risk of disturbance from land management activities. Interagency Vegetation Mapping Project data indicate that at least 10 percent of the land area consists of agricultural and/or urban lands. Wetlands on agricultural and urban lands may have been filled-in or otherwise degraded, and wetlands that persist in these settings may face an elevated relative risk. Additional effort may be needed to ensure that management on trust lands in these watersheds does not contribute to potentially significant adverse cumulative effects on wetlands. DNR current policy (Forest Resource Plan No. 21), HCP, and current procedure (PR 14-004-110) specify that wetlands require significant protection, and stipulate no overall net loss of wetlands due to state land management. See Section 4.9 (Wetlands) for an assessment of the risks to wetlands from forest management activities.

4.15.3.4 Summary of Environmental Effects on Forest Conditions and Wildlife Habitat

The current conditions of the forests and wildlife habitats vary in the watersheds where DNR manages western Washington forested trust lands. The outstanding forest condition that lacks substantial acreage across all watersheds is forests with large/very trees. These forests are an indicator of structurally complex forests; forests that provide certain key

Table 4.15-10. Areas with an Elevated Potential for Development Where Wetlands Have Been Identified

HCP Planning Unit	Number of Watersheds[1/]	Average Area of Wetlands	Average Percentage of Land Area in Different Land Classes or Ownerships			
			Agriculture	Urban	DNR	Private
Columbia	9	0.04%	21%	5%	12%	83%
N. Puget	14	0.15%	16%	5%	19%	78%
S. Coast	9	0.18%	17%	3%	26%	72%
S. Puget	2	0.07%	3%	14%	23%	68%
Straits	1	0.01%	33%	2%	13%	62%
Westside	***35***	***0.12%***	***17%***	***5%***	***19%***	***77%***

Data Source: DNR MASK Geographic Information System layer.
[1/] The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations.

habitats for wildlife and plant species in western Washington. All the Alternatives project improvements in structurally complex forest on forested trust lands over time. The Preferred Alternative has the greatest potential to increase structurally complex forest through implementation of silvicultural systems that promote structural diversity in forest stands (biodiversity pathway management).

This increase in structurally complex forest on forest trust lands will have the greatest potential for a positive impact in watersheds where state trust ownership is greatest. For other watersheds, where the state trust ownership is small, the development of structurally complex forest will be dependent upon other landowners. Federal management of forestlands is currently assumed to be dominated by passive management pathways, with few acres receiving silvicultural treatment. Large private forest ownership is, in general, assumed to be focused on commercial timber production unless the ownership has an HCP with the Federal Services (this includes National Oceanic and Atmospheric Administration – Fisheries Service and U.S. Fish and Wildlife Service). Nonindustrial landownership consists of mixture of passive and commercial timber management and forest conversion activities. Based on the analysis of the Alternatives presented in this Final Environmental Impact Statement (see Section 4.2.2, Forest Structure and Vegetation) that examined a range of both passive and commercial timber management options, neither passive nor industrial management approaches are likely to offer substantial improvements in structural complex forest in the near or long term. Model outputs indicate that biodiversity pathways management proposed under the Preferred Alternative provides the best opportunity to accelerate the development of structural complex forest and provides the most fully functionally forest over the life of the HCP (see Table 4.2-8).

4.15.4 Fish

Several factors influence the potential for forest management to contribute to significant adverse cumulative effects to fish resources. These factors include the presence of fish or fish habitat, the existing condition of these resources, geomorphologic processes, and the frequency and intensity of management activities. The location of management activities also plays a role. Activities in the riparian area may influence the potential for adverse effects, as well as those in upslope areas with the potential to deliver significant amounts of sediment into the aquatic ecosystems. Activities in areas of unstable slopes (and an elevated risk of mass wasting) may increase the potential for sediment delivery, while those in significant rain-on-snow zones may alter the timing and magnitude of peak stream flows.

Areas that have more fish resources (as indicated by stream density per square mile or miles of stream per square mile of land) are considered to be potentially more at risk to cumulative effects. Similarly, areas that have higher levels of past disturbance (e.g., small riparian trees) or potential future disturbance (unstable slopes) are considered to be potentially at higher relative risk of showing adverse cumulative effects currently or in the future. Finally, management strategies on different ownerships can result in different levels of future activities. Higher levels of activity are considered to have a higher relative potential to contribute to significant adverse cumulative effects. Federal ownership is expected to result in few forest management activities under the Northwest Forest Plan, while private forest ownership, except in areas covered by private forestland HCPs, is expected to result in more intensive and frequent management as compared to western Washington forested trust lands. The level of forest management activities in riparian areas proposed on forested trust lands may be relatively low (Alternatives 1 and 4) or relatively high (Alternatives 5 and the Preferred Alternative) depending on the Alternative chosen.

In general, fish resources and their habitat would be expected to improve in the long term because of the Northwest Forest Plan, improved Forest Practices Rules, and various habitat conservation plans being developed and implemented in the region. Each of these landscape-level plans has a goal of protecting and restoring fish resources in the Pacific Northwest. Nevertheless, forest management activities are expected to continue in the region. The risk of adverse cumulative effects needs to be evaluated in light of these activities, current conditions, and the previously identified legal, contractual, and policy constraints.

The cumulative effects analysis for fish resources uses the watershed as the spatial scale for analysis, and the planning unit as the scale for summarizing them.

The cumulative effects analysis for fish resources integrates a number of measures for each watershed. These include the following:

- Percent of forested trust lands ownership in the total watershed area (Appendix E, Table E-20);
- Percent of riparian area with small trees (a quadratic mean diameter of less than 10 inches) (Appendix E, Table E-21)
- Anadromous fish stream length and stream density (stream miles per square mile) (Appendix E, Table E-22);
- Total stream length and stream density (stream miles per square mile) (Appendix E, Table E-23);
- Resident fish stream density (Types 1 to 3 stream miles per square mile) (Appendix E, Table E-24);
- Bull trout stream density (bull trout stream miles per square mile) (Appendix E, Table E-25);
- Percent of watershed area with urban or agricultural land use (Appendix E, Table E-26);
- Percent of rain-on-snow area with hydrologically immature forest (see Section 4.7, Hydrology) (Appendix E, Table E-22);
- Miles of stream on the 303(d) list for temperature (see Section 4.8, Water Quality) (Appendix E, Table E-13);
- Miles of stream on the 303(d) list for dissolved oxygen (see Section 4.8, Water Quality) (Appendix E, Table E-14);
- Miles of stream on the 303(d) list for fine sediment (see Section 4.8, Water Quality) (Appendix E, Table E-15); and
- Percent of watershed area assessed as having a high rating for shallow rapid landslides (see Section 4.6, Geomorphology, Soils, and Sediment) (Appendix E, Table E-29)

The available information (summarized in Table 14.5-15) indicates that the highest average proportion of watersheds that may be experiencing cumulative effects (i.e., the watershed is present in the upper quartile for the resource measures described listed above) was in the North Puget HCP Planning Unit (an average of about 33 percent of watersheds in the upper quartile), followed by the Olympic Experimental State Forest (about 17 percent), Columbia (about 16 percent), South Coast (about 14 percent), South Puget (about 6 percent), and Straits (about 6 percent) HCP Planning Units.

If each HCP Planning Unit is examined individually, then the Olympic Experimental State Forest has the highest number of watersheds (about 33 percent) that have resource areas that may be experiencing cumulative effects (i.e., the watershed is present in the upper quartile for the resource measures described listed above). The Olympic Experimental State Forest is followed by South Coast (about 26 percent), North Puget (about 24 percent), Columbia (about 19 percent), South Puget (about 17 percent), and Straits (about 14 percent). Based upon this summary information, the relative potential for existing adverse cumulative effects to fish resources is highest for the North Puget and Olympic Experimental State Forest HCP Planning Units, moderate for the Columbia and South Coast HCP Planning Units, and relatively low for the South Puget and Straits HCP Planning Units. Individual watersheds may have a higher or lower potential for existing adverse cumulative effects to fish resources than these planning unit averages.

The relative potential of future adverse cumulative effects is related to a large number of factors that include conditions in the marine environment and fisheries management (for anadromous fish), current conditions, and the intensity and type of future forest management activities in riparian areas. The focus of this analysis will be on the last two factors. Upslope activities on unstable areas that result in large mass movements may affect fish resources by contributing sediment to streams. Slope stability cumulative effects are addressed in Section 4.15.5.6. Consequently, the relative potential for future cumulative effects from activities on western Washington forested state trust lands may be highest under Alternative 5 and the Preferred Alternative compared to other Alternatives. However, thinning dense stands of small and medium trees (trees under 20 inches in diameter) in combination with other habitat enhancement activities as proposed in the Preferred Alternative would be expected to improve riparian conditions over time. The forest management activities associated with the riparian restoration activities in the Preferred Alternative are based on biodiversity pathways management and are likely to enhance the development of fully functional riparian forests for a larger area in an earlier timeframe. Therefore, the near-term relative risks of some adverse cumulative effects from tree removal and ground disturbance may be higher under the Preferred Alternative compared to Alternatives 1 through 4, which have relatively low levels of management activities in riparian areas. On the other hand, the current levels of potential adverse cumulative effects that result from having less-than-fully functional riparian areas are expected to decline more rapidly from active management under the Preferred Alternative compared to other Alternatives.

4.15.4.1 Evaluation of Potential Cumulative Effects to Fish

Under all of the Alternatives, riparian management activity on forested state trust lands is designed to achieve stand development stages at and beyond understory initiation (see Table 4.2-4). Most of the riparian management activities would occur concurrent with adjacent upland forest management activities.

Based upon the current best reasonably available information, the relative potential for existing adverse cumulative effects to fish resources from the proposed Alternatives is highest for the North Puget Habitat Conservation Plan (HCP) Planning Unit, followed by the Olympic Experimental State Forest, and then the Columbia, South Coast, South Puget, and Straits HCP Planning Units. The relative potential of future contributions to adverse cumulative effects is assumed to be related to current conditions and the intensity and type of future forest management activities in riparian areas. Consequently, the relative potential for future cumulative effects from activities on forested trust lands may be highest under Alternative 5 and the Preferred Alternative compared to other Alternatives. Under the Preferred Alternative riparian stands in the competitive exclusion stage will have a high priority for thinning activity. The forest management activities associated with these riparian harvests in all HCP Planning Units in the Preferred Alternative are generally based on biodiversity pathway management and are likely to enhance and accelerate the development of fully functioning riparian forests for a larger area in an earlier time frame. The relative risks of some adverse cumulative effects from tree removal and ground disturbance may be higher under the Preferred Alternative, as compared to Alternatives 1 through 4, which have relatively low levels of management activities in riparian areas. On the other hand, the current levels of adverse cumulative effects that result from having less-than-fully functioning riparian areas are expected to decline more rapidly under active management.

4.15.5 Water Resources

4.15.5.1 Hydrology

Hydrologically mature forest is defined as a conifer-dominated forest having a relative density of at least 25 on Curtis' relative density index scale and a stand age of 25 years or older. Hydrologic immaturity is therefore defined as any forested area that is younger than 25 years old, or that has a relative density of less than 25 (HCP, page IV 68). The significant rain-on-snow zone varies with location, but typically is found between elevations of approximately 1,000 and 3,000 feet above sea level. Of the 179 watersheds in which forested trust lands make up at least 5 percent of the total ownership, 159 of these also have areas of hydrologically immature forest in the rain-on-snow zones. These areas are summarized by ownership in Appendix E, Table E-27.

As discussed in the Forest Practices Rules Final Environmental Impact Statement (2001), Section 3.3, pages 3-27 and 3-28, three primary processes affect the hydrologic functions of forested watersheds: 1) precipitation and water flow regimes (i.e., flow with respect to time) largely controlled by climate; 2) the role of vegetation in intercepting precipitation and controlling the amount of water, including snow:rain ratio, that reaches the forest floor; and 3) the role of surface and subsurface pathways that deliver surface runoff and subsurface water to streams. Forest management can affect the hydrology of forested watersheds by affecting annual water yield, low flows, and peak flows. Of these effects, the rate and types of harvest under certain circumstances can significantly affect peak flows. Changes in peak flows may lead to slope failure or increased incision and erosion of stream channels depending on local geomorphologic processes. Increasing the forest canopy within the watershed can lessen these effects. Maintaining or increasing hydrologic maturity within the significant rain-on-snow zones can particularly lessen the effects.

4.15.5.2 Evaluation of Potential Cumulative Effects to Hydrology

None of the Alternatives would alter the existing policies and procedures related to management of significant rain-on-snow zones. In all of the Alternatives, the percentage of mature forest on forested trust lands within the "significant" rain-on-snow zones (the rain on snow and snow-dominated zones) of watersheds would not drop below 66 percent, as defined in the Habitat Conservation Plan (HCP) (page IV. 68) and procedure 14-004-060. As shown in Appendix E, Table E-27 and discussed in Appendix E, the Olympic Experimental State Forest has the largest percent of immature forest in the significant rain-on-snow zones under DNR ownership, meaning that this is the HCP Planning Unit in which DNR carries the greatest relative risk for increasing peak flows relative to other ownerships. Management intensity at the watershed level (indicated by number watersheds having a 20 percent of more of forested trust land regenerated during the first decade) in the Olympic Experimental State Forest is presented by Alternative in Table 4.15-11. Alternatives 1, 3, and 4 would appear to present the least intensive management for the Olympic Experimental State Forest in the first decade. Alternative 5 would present the greatest risk to increasing peak flows in potentially eight watersheds, while Alternative 2 and Preferred Alternative demonstrate intermediate positions. This ranking of Alternatives is similar for the other planning units, with Alternative 5 presenting the most watersheds with relatively high regeneration harvest levels and the Preferred Alternative an intermediate rank.

4.15.5.3 Water Quality

Water quality was evaluated in terms of the miles of stream listed under 303(d) for temperature, fine sediment, and dissolved oxygen in each of the 179 watersheds with greater than 5 percent DNR ownership. There were no 303(d) listings in these watersheds for phosphorous or other nutrients. The purpose of the analysis was to determine which planning units and watersheds would be at risk for decreased water quality due to proposed changes in harvest levels on forested trust lands. See Appendix E and Appendix E, Tables E-12, E-14, and E-15.

Table 4.15-11. Number of Watersheds by HCP Planning Unit and Alternative with a Modeled Regeneration Harvest Area of 20 Percent or Greater of Forested Trust Lands in Watersheds Where Forest Trust Lands Amount to 22 Percent or More of the Watershed Area

	HCP Planning Unit					
Alternatives	**Columbia**	**North Puget**	**South Coast**	**South Puget**	**Straits**	**OESF**
1	2	3	1	0	2	0
2	1	2	5	1	1	2
3	4	1	6	1	4	0
4	6	6	9	1	1	0
5	8	3	9	8	6	8
PA	8	4	5	3	1	2

PA = Preferred Alternative
OESF = Olympic Experimental State Forest

4.15.5.4 Evaluation of Potential Cumulative Effects to Water Quality

As discussed in Section 4.8, Alternatives 2 through 5 and the Preferred Alternative would include increased harvest in riparian areas, meaning that there would be a relative risk of reduced shade and increased sedimentation in the short term with these Alternatives. While no harvest is proposed for the inner Riparian Management Zones in any of the Alternatives, the Preferred Alternative does model patch cuts of greater than 1 acre as part of its biodiversity pathway approach to Riparian Management Zones. These patches could increase the risk of blowdown and slightly increasing relative risk of fine sediment input to streams. Harvest intensity could affect the amount of road traffic, increasing the risk of fine sediment input to streams. Additionally, of the Alternatives proposed, only Alternative 5 and the Preferred Alternative would increase fertilizer use. These two Alternatives, with higher harvest rates and some use of fertilizers, have the highest relative risk for decreasing dissolved oxygen levels on listed streams. While the long-term and landscape-level risks are low for water quality under implementation of any of the Alternatives, the 303(d) stream listings may be used as an allocation tool for planning resources to assess water quality and forest management interactions.

4.15.5.5 Slope Stability and Soils

Slope stability and soil productivity are critical variables in protecting the environment and maintaining harvest levels, as discussed in the Forest Practices Rules Final Environmental Impact Statement (2001, pp. 3-5 through 3-8) and this document (Section 4.6). Both parameters are analyzed here based on slope stability, soil characteristics, and ownership data, and are discussed below.

4.15.5.6 Slope Stability

None of the Alternatives change DNR's policies and procedures in the management of slope stability. Slope stability has been modeled for all watersheds in the study area using the Shaw-Johnson model for slope stability (Shaw and Johnson 1995). Appendix E, Table E-29 contains data for areas classified as "high" for potential slope instability. Appendix E, Table E-30 contains data for areas classified as "moderate" for potential slope instability. Evaluation using the Shaw-Johnson model is one of the methods used to initially identify areas of potential slope instability for DNR procedure 14-004-050, Assessing Slope Stability. If this method is used to determine slope stability, the areas identified using the Shaw-Johnson model must then be field-verified by qualified staff. Management operations, including timber harvest, are then determined. The current process for prevention of slope failure is a function both of identification of potentially unstable areas and careful planning of operations in those areas.

Slope stability rankings, as determined by the Shaw-Johnson model, vary regionally with topographic relief. The average percent area by watershed that is classified as high for potential slope instability is shown for each planning unit in Table 4.15-12.

DNR ownership of these areas does not vary significantly among planning units from the average for western Washington forested state trust lands. The North Puget HCP Planning Unit and the Olympic Experimental State Forest have the highest percent areas classified, as a result of modeling, as high for potential slope instability. Additionally, of 45 watersheds ranked in the top quartile for percent area classified as high for potential slope instability, nine have majority DNR ownership of these lands. These nine watersheds are in either the North Puget or Olympic Experimental State Forest HCP Planning Units, as shown in Appendix E, Table E-29.

Existing DNR policies and procedures and Forest Practices Rules require specialist resources to identify any potentially unstable areas on which management is proposed. As

Table 4.15-12. Average Percent Area Classified as High for Potential Slope Instability by HCP Planning Unit and Ownership

HCP Planning Unit	Number of Watersheds[1/] Analyzed	Average Percent of Watershed Acreage Classified as High	Percent of Area Classified as High for Potential Slope Instability by Ownership			
			DNR	Federal	Private	Other
Columbia	38	7.5%	21%	13%	64%	1%
North Puget	61	17.1%	27%	36%	34%	2%
OESF	23	16.2%	39%	29%	28%	4%
South Coast	24	11.3%	27%	0%	70%	3%
South Puget	15	10.0%	38%	18%	39%	5%
Straits	18	13.5%	25%	50%	24%	1%
Average		**12.6%**	**30%**	**27%**	**40%**	**3%**

Data Source: DNR MASK Geographic Information System layer.
OESF = Olympic Experimental State Forest
[1/] The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations.

the Shaw-Johnson model has not been calibrated for all areas on state trust forests in western Washington, the potential relative risks for proposed Alternatives is discussed qualitatively.

Landslide risk is a function of physical conditions, policy, and management activities. Given current conditions across the landbase and no changes in the proposed policies related to landslides under any of the alternatives, relative risk can be evaluated in terms of the proposed harvest levels and resources required to prevent or mitigate landslide hazards. Alternatives that propose higher levels of harvest in the North Puget HCP Planning Unit and Olympic Experimental State Forest HCP Planning Units, and increased harvest intensity in general, would pose a slightly higher risk in terms of the necessity for additional resources devoted to assessment and planning for management activities on potentially unstable slopes.Therefore, Alternatives are ranked from lowest to highest for the relative need to evaluate forest management activities on potentially unstable slopes by the amount of regeneration harvest area (expressed as greater than 20 percent of the forest trust land ownership in a watershed) during the first decade. Table 4.15-13 presents the number of watersheds with regeneration harvests from the upper quartile group identified with high potential slope instability. North Puget HCP Planning Unit and the Olympic Experimental State Forest have the greatest number of watersheds with regeneration activities. Alternatives 1 and 4 demonstrate the least number of watersheds during the first decade with regeneration areas greater than 20 percent of the state trust ownership in the watershed, while Alternative 5 presents the most in this category.

Under all Alternatives and in all HCP Planning Units, but especially in the North Puget and Olympic Experimental State Forest, DNR will continue to plan and design regeneration harvest activities that minimize the risk of slope failure by following its current policy and procedures.

Table 4.15-13. Number of Watersheds from the Upper Quartile Rank with High Potential Slope Instability with Regeneration Harvests in the First Decade

	Colombia		North Puget		OESF		South Coast		South Puget		Straits	
	Percent of Forested Trust Lands Area Generated during the First Decade											
Alternatives	0-20%	>20%	0-20%	>20%	0-20%	>20%	0-20%	>20%	0-20%	>20%	0-20%	>20%
1	4	1	19		8		2		1		4	
2	5		18	3	7	1	2		1		3	1
3	5		21		8		2		1		1	3
4	3	2	20	3	8		1	1	1		2	2
5	4	1	19	4	6	2	2		1			4
PA	4	1	21	1	7	1	2		1		4	

PA = Preferred Alternative
OESF = Olympic Experimental State Forest

4.15.5.7 Soil Compaction

Soil compaction can reduce site productivity by reducing the permeability and porosity of soil, making it more difficult for roots and water to penetrate the soil. Soil compaction can also influence hydrology by reducing the ability of soil to hold water. Soil compaction potential is a determination of the potential for moist soils to be compacted. Compaction of moist soils can occur during harvest. Harvest practices vary in the amount of compaction resulting in susceptible soils. Ground-based logging practices generally compact and disturb more soil area than practices using partial or full suspension of logs. Policies and procedures in use by DNR to protect soil from compaction are discussed in Appendix C. Compaction effects from timber harvest may be short-lived, especially in coastal Washington, where reduced height of Douglas-fir in skid trail areas compared to nonskid trail areas was found to last only 2 years (Heninger et al. 2002).

Compaction potential varies regionally, with climate and soil type, but sensitivity of soils to compaction is a characteristic common to all of the 179 watersheds considered here for cumulative effects. Both “high” and “moderate” rated moist soil compaction potential data were analyzed, but only high compaction potential soil areas are discussed here. See Appendix E, Tables E-31 and E-32 for the analysis of all 179 watersheds.

Table 4.15-14 shows the percent area of planning units that have soils classified as high for potential for moist soil compaction. Four of the six HCP Planning Units, and therefore a majority of the total area under DNR management, are dominated by soils classified as high for moist soil compaction.

Of the 45 watersheds in the top quartile for percent area classified with a high potential for moist soil compaction, all have at least 83 percent of their area classified as high for this parameter. Therefore, it can safely be assumed that in those 45 watersheds, there is a high probability that any planned harvest would occur on soils that could be considered at risk for compaction during moist soil conditions, regardless of ownership.

Table 4.15-14. Average Percent Acreage Classified as High for Moist Soil Compaction Potential

HCP Planning Unit	Average Percent Acreage Classified as High	Percent of Area Classified as High for Potential for Soil Compaction by Ownership			
		DNR	Federal	Private	Other
Columbia	64%	20%	1%	77%	2%
North Puget	57%	32%	3%	62%	3%
OESF	62%	39%	3%	55%	4%
South Coast	89%	31%	0%	64%	5%
South Puget	27%	38%	1%	49%	11%
Straits	18%	37%	4%	57%	2%

Data Source: DNR MASK Geographic Information System layer.
OESF = Olympic Experimental State Forest

A total of 107 of the 179 watersheds evaluated have greater than 50 percent of the soils rated as having high moist soil compaction potential. Of the 107 watersheds, DNR owns 50 percent or more of the watershed area identified as having high moist soil compaction potential in 17 watersheds. Of these 17, six watersheds rank in the top quartile for percent area classified as high for moist soil compaction potential, as shown in Table 4.15-12. These six watersheds would be the watersheds in which DNR's activities would have the most relative influence in terms of maintaining soil productivity and function in the watershed under the proposed Alternatives.

DNR policies and procedures described in Chapter 2 and Appendix C give general guidance for the timing and type of harvest operations to prevent unnecessary compaction as a result of harvest. As a result of this guidance, the relative risk of increased soil compaction is generally low, regardless of Alternative. The majority of the watersheds in which DNR manages more than 5 percent of the land area are dominated by soils classified as high for potential moist soil compaction. In addition, more intensive harvests would likely result in a greater amount of compaction. Therefore, the relative risk of compaction under each Alternative would be a function of two main factors: 1) total acreage disturbed by higher volume removal harvest activities (greater than 20 thousand board feet per acre) on moist soils, and 2) total acreage disturbed by all harvest activities. The Alternatives can be ranked from least to greatest risk for potential soil compaction as follows: Alternatives 1 and 4 would be essentially the same, followed by the Preferred Alternative and Alternatives 2, 3, and 5.

4.15.6 Potential Impacts of Future Harvests

4.15.6.1 Summary of Current Conditions

Of the 179 watersheds in which DNR manages western Washington forested state trust lands, 83 have a forested trust land ownership level of 22 percent or greater of the total watershed area (these watersheds are referred to hereafter as the "83-group"). The threshold of 22 percent, although appearing arbitrary, represents the upper quartile rank of the forested trust land ownership as a percent ownership in all watersheds that DNR manages lands in western Washington (see Section 4.2.4.2, Forest Structure and Vegetation and Appendix E for more details). Thus, the 83-group represents the watersheds where DNR has the greatest potential to influence current and future cumulative effects, because these are the watersheds where the DNR manages most land.

Use of the "quartile" and "upper quartile" in this analysis is principally used as a screening tool for identifying the potentially "worst-case scenario.". The majority of the resource areas that this environmental analysis examines do not have sufficient reasonably available data to make precise descriptions about the current conditions that exist in a watershed. In addition, making a resource assessment of current or future conditions based upon these best available data would likely result in somewhat arbitrary judgments about whether the conditions are "good" or "poor.". Therefore, the use of statistics (in this case quartiles) provides an alternative method to highlight the most extreme conditions and events (disturbances causes by regeneration harvests) in relative terms of all the conditions that DNR manages in western Washington. As the upper quartile rank of conditions and events represents the potentially “worst-case” situations that may occur, these are analyzed and considered for potential cumulative effects.

Table 4.15-15 summarizes the spatial distribution of the upper quartile rank of 10 resources areas across the five HCP Westside Planning Units and the Olympic Experimental State Forest. Only 9 watersheds out of the 83-group were found to have no occurrences of any of the 10 resource areas represented in the upper quartile (see Table 4.15-16). In other words, the majority of the 83-group of watersheds in which DNR manages 22 percent or more of the land may have existing and/or may be sensitive to future impact of cumulative effects. The majority of the 83-group of watersheds has at least 1 and potentially multiple occurrences of indices ranked in the upper quartile. Therefore, forest management activities, such as harvesting timber, could have potential cumulative effects on these 10 key resources, the 74 remaining watersheds where DNR management has the greatest ownership.

Table 4.15-17 characterizes the resource areas that appear most frequently in the 83-group of watersheds. From the data presented in the Table 4.15-17, the most common resource areas listed are the amount of small diameter, open forests (see Section 4.15.3.1 for a definition), potential slope instability, and resource areas related to riparian and fish resources within these watersheds. These resource areas have been identified from the Geographic Information System data. Other resources areas such as cultural, scenic, and recreational resources also may be important. In part, these resources (not readily captured in Geographic Information System data) may be associated with the amount of small diameter, open forests and are discussed in Sections 4.12, 4.13, and 4.14.

Table 4.15.15. Number of Watersheds in the Upper Quartile, Percent of Upper Quartile, and Percent of Watersheds in a Planning Unit with at Least 5 Percent Forested Trust Lands Ownership

	Columbia			South Coast			Olympic Experimental State Forest			Straits			North Puget			South Puget			
Measure	Number	% of Upper Quartile	% of Planning Unit watersheds	Number	% of Upper Quartile	% of Planning Unit watersheds	Number	% of Upper Quartile	% of Planning Unit watersheds	Number	% of Upper Quartile	% of Planning Unit watersheds	Number	% of Upper Quartile	% of Planning Unit watersheds	Number	% of Upper Quartile	% of Planning Unit watersheds	Total Number of watersheds in Upper Quartile
Small Trees	11	24.4%	28.9%	9	20.0%	37.5%	6	13.3%	26.1%	5	11.1%	27.8%	6	13.3%	9.8%	8	17.8%	53.3%	45
Bull Trout Stream Density	3	6.7%	7.9%	2	4.4%	8.3%	5	11.1%	21.7%	1	2.2%	5.6%	33	73.3%	54.1%	1	2.2%	6.7%	45
Anadromous Fish Stream Density	2	4.4%	5.3%	7	15.6%	29.2%	16	35.6%	69.6%	0	0.0%	0.0%	18	40.0%	29.5%	2	4.4%	13.3%	45
Resident Fish Stream Density	3	6.7%	7.9%	11	24.4%	45.8%	12	26.7%	52.2%	1	2.2%	5.6%	16	35.6%	26.2%	2	4.4%	13.3%	45
Stream Density	19	42.2%	50.0%	15	33.3%	62.5%	6	13.3%	26.1%	0	0.0%	0.0%	1	2.2%	1.6%	4	8.9%	26.7%	45
Hydrologic Maturity in Significant Rain-on-Snow Zones	20	44.4%	52.6%	0	0.0%	0.0%	5	11.1%	21.7%	4	8.9%	22.2%	11	24.4%	18.0%	5	11.1%	33.3%	45
303(d) list for temperature	4	8.9%	10.5%	4	8.9%	16.7%	13	28.9%	56.5%	5	11.1%	27.8%	16	35.6%	26.2%	3	6.7%	20.0%	45
303(d) list for fine sediment	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	4.4%	3.3%	0	0.0%	0.0%	45
Shallow rapid landslides	1	2.2%	2.6%	1	2.2%	4.2%	8	17.8%	34.8%	5	11.1%	27.8%	29	64.4%	47.5%	1	2.2%	6.7%	45
Urban and Agricultural Land Use	10	22.2%	26.3%	9	20.0%	37.5%	1	2.2%	4.3%	6	13.3%	33.3%	17	37.8%	27.9%	2	4.4%	13.3%	45
Average	7.2	16.0%	18.9%	6.2	13.8%	25.8%	7.5	16.7%	32.6%	2.6	5.8%	14.4%	14.6	33.1%	23.9%	2.6	5.8%	17.3%	
Number of watersheds with at least 5% DNR ownership		38			24			23			18			61			15		179

Table 4.15-16. Distribution of Watersheds with Multiple Resource Areas Represented in the Upper Quartile from Watersheds That Have at Least 22 Percent State Trust Land ownership

Frequency of occurrences (upper quartile for the 10 resource areas)	HCP Planning Unit						
	Columbia	**South Coast**	**OESF**	**Straits**	**North Puget**	**South Puget**	**Total**
0	1	1	2	2	3		**9**
1	5	5	3	2	6	5	**26**
2	3	1	2	1	11	2	**20**
3	2	3	3	2	4	1	**15**
4	1		3			1	**5**
5		1	2		1	1	**5**
6		1			1		**2**
7			1				**1**
Total	**12**	**12**	**16**	**7**	**26**	**10**	**83**

Table Notes:
Values in the table represent number of watersheds.
The 10 select resource areas are listed in Table 4.15-15. The frequency of occurrences represents multiple resources areas.
OESF = Olympic Experimental State Forest

Table 4.15-17. Occurrences of the 10 Listed Resources from Table 14.15-15 in the 83-group of Watersheds

Resource Acres	Tally of Occurrences That an Upper Quartile Resource Areas is Present in a Watershed							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Overall**
Small diameter, open forests	6	8	4	3	2	0	0	23
Anadromous streams	1	1	8	5	5	2	1	23
Bull trout streams	3	7	6	1	2	2	1	22
Stream density and length	3	0	7	4	4	1	1	20
Resident fish streams	0	1	6	4	4	2	1	18
Agricultural area	3	6	4	0	2	2	0	17
High potential slope instability	4	6	3	0	2	0	1	16
Hydrologically immature forests in the rain-on-snow zone	3	6	2	1	2	0	1	15
Urban area	3	4	4	0	1	1	0	13
303(d)streams listed for temperature	0	1	0	2	1	2	1	7
303(d) streams listed for fine sediment	0	0	1	0	0	0	0	1

Table notes:
Values in the table represent number of times the resource occurs.
Sample is the 83-group of watersheds with a resource area represented in the upper quartile and forest trust ownership is greater than 22 percent of the watershed area.

The analysis of open forests, potential slope instability, and resource areas related to riparian and fish resources, would suggest that future DNR management would require site-specific assessment of the actual current conditions. This assessment may lead to the development of landscape and/or site-specific strategies to ensure adequate protection of the specific resources.

4.15.6.2 Rates of Harvest

Table 4.15-18 identifies watersheds by Alternative from the "83-group" that may have relatively higher levels of regeneration harvest. Table 4.15-18 identifies watersheds where the Alternative's modeling outputs indicate regeneration harvest levels of greater than 20 percent of the forest trust ownership within a watershed over 7 decades. It is important to remember that the model was developed to help inform policy and not to set watershed specific harvest schedules. However, the Table 4.15-18 may be useful in distinguishing and ranking the Alternatives.

From the harvest report presented in Table 4.15-18, a pattern of three groups distinguishes the Alternatives from one another. Alternatives 1, 2, and 3 have a relatively low number of watersheds with a total regeneration harvest over 20 percent per decade. The Preferred Alternative and Alternative 4 illustrate an intermediate number of watersheds. Alternative 5 presents the highest range.

Beyond the first decade, the Preferred Alternative and Alternative 1 project a similar pattern of a small number of watersheds from the "83-group" that have modeled total decadal regeneration harvest over 20 percent.

Table 4.15-18. Number of the 83-Group Watersheds That Have a Modeled Decade Levels of Regeneration Harvest Greater than 20 Percent[1/] of the Forested Trust Land in the Watershed by Alternative and Decade

Decade[2/]	Alternatives					
	1	2	3	4	5	PA
1	11	14	16	25	42	24
2	10	18	27	24	53	4
3	5	8	6	19	53	2
4	6	10	10	6	57	7
5	6	12	30	17	27	7
6	7	14	24	14	34	8
7	0	0	0	0	0	0

[1/] The total harvest is calculated separately for each decade and watershed. The percentage is of the forested trust lands ownership in a watershed.
[2/] Only 4 years of harvests are during the last decade (2064-2067), which is not enough for any watersheds to cross the threshold under any of the alternatives necessary to be listed in this table.
PA = Preferred Alternative

The Preferred Alternative's reduction after the first decade is largely due to the following factors:

- higher regeneration acres in the first decade in stands not suitable for long-rotation heavy thinning biodiversity pathway management (see Section 4.2.4, Forest Structure and Vegetation), and a
- greater proportion in subsequent decades' landscapes managed with thinnings and partial harvests, thereby reducing the area of regeneration harvests.

4.15.6.3 Policy Context

All Alternatives implement the DNR Habitat Conservation Plan (HCP) strategies. The HCP riparian management strategy is a core component used to achieve many of its major conservation objectives. The combination of the riparian conservation strategy and the supportive silvicultural activities designed to restore conditions has been described in detail in Chapter 2. Implementation of restoration activities under the Preferred Alternative is likely to increase the probability of improving riparian conditions within the foreseeable future as opposed to other Alternatives, such as 1 and 4, which restrict active riparian restoration activities (see Section 4.3). Alternatives with less management in the riparian, including Alternatives 1 and 4, will rely on natural disturbances and forest succession to develop structurally complex forests and improve riparian conditions. While succession and natural disturbances will happen, the changes could take a long time (Franklin et al. 2002).

None of the Alternatives propose changes to DNR management of potential slope instability. Management direction for potentially unstable slopes conditions is found in the current HCP, DNR's procedure, and Forest Practices Rules (see Section 4.6 for more details).

The Alternatives differ in their procedural approach to small diameter, open forests. The only current procedural direction that addresses the amount of small diameter, open or "young" forests (at the watershed scale) is found in a portion of Task 14-001-010 – Maintenance of Mature Forest Components. Under this task, DNR forest managers are directed to maintain at least 50 percent of forested trust lands within a watershed in a condition of 25 years or older. This rule, commonly known as the"50-25 rule," is applied to all watersheds where forested trust lands ownership is at least 5 percent of the watershed area or greater.

The "50-25 rule" was introduced in 1999, and related to circumstances surrounding the HCP's adoption. Even before the HHCP was signed in 1997, litigation was filed that attempted to block its implementation. A fundamental concept in any HCP is that it must provide adequate mitigation for any incidental "taking" of the species covered by the plan. Thus, the litigation carried with it a risk that if an adverse court ruling invalidated DNR's agreement to the HCP, DNR would *still* need to provide mitigation for any "taking" that occurred while it operated under the plan. To reduce this risk, DNR temporarily deferred timber harvests within Status-1-Reproductive and Southwest Washington owl circles. Simultaneously, DNR also deferred harvest activities under in 56 of the 66 critical northern spotted owl circles described in HCP Memorandum #1 (Section 4.4). DNR's temporary deferral of harvests within all Status-1-Reproductive and Southwest Washington northern spotted owl circles was not anticipated in the HCP or the 1996 sustainable harvest calculation.

The implications of the previously identified risk management strategies raised some questions. In particular, a large area (approximately 314,000 acres in 115 northern spotted owl circles) had been placed "off-base" to timber harvest, if only temporarily, without any adjustment in the statewide harvest level. The result was a likely increase in timber harvesting in other non-deferred or on-base areas. DNR foresaw that if the "temporary" harvest restrictions continued for some time, harvest rates in watersheds with fewer constraints might climb. Without the benefit of thorough landscape level analysis to reveal the potential of the concern, DNR introduced the "50-25 rule" in an attempt to prevent "over-harvesting" in less constrained watersheds (Task 14-001-010, 1999). The rule borrows from the concepts used in DNR's HCP strategies for management of the "significant rain-on-snow" areas based on the hydrologic principles contained in the 1991 emergency state Forest Practices Rules on rain-on-snow (HCP, IV.75).

Alternative 1 is the only Alternative to maintain the "50-25 rule" portion of the task, while Alternatives 2, 3, 4, 5, and the Preferred Alternative replace this portion of the task with the recognition that DNR forest managers use the State Lands Timber Sale expanded State Environmental Policy Act checklist to assess for cumulative effects of timber harvest activities.

The modeling of the Alternatives provides an opportunity to examine the impacts of the proposed changes in the Task. Table 4.15-19 presents the number of watersheds for the 83-group that are estimated to have less than 50 percent of their area in forest of an age 25 years or older. For details on the all watersheds, please refer to Appendix E.

Table 4.15-19. Estimated Number of Watersheds from the "83-group" Having Less Than 50 Percent of Their Forested Trust Lands Area in Forest 25 Years or Older

Alternative	2004	2013	2031	2067
1	1	0	0	0
2	1	0	0	0
3	1	0	1	0
4	1	0	0	0
5	1	0	0	0
PA	1	0	0	0

PA = Preferred Alternative

If all watersheds where DNR manages at least 5 percent of the watershed are considered, then there are also only small differences between the Alternatives (Table 4.15-20) in terms of the number of watersheds that do have more than 50 percent of their area at 25 years or older.

The "50-25 rule" is proposed to be replaced by targeted analyses addressing site-specific considerations. DNR has developed a specially expanded version of the State Environmental Policy Act Environmental Checklist. Beyond completing all legally required analyses within Department of Ecology's (standard) Environmental Checklist, DNR has integrated over 100 additional questions into the (expanded) Environmental Checklist. These additions are designed to more fully explore the environmental implications, including cumulative effects, of proposed sustainable forestry actions.

4.15.6.4 Summary of Potential Impacts of Future Harvests

For the watersheds where DNR management is most likely to have a potential impact on multiple resource areas (i.e. from the 83-group of watersheds), the "50-25 rule" appears to have no meaningful effect on the condition of the watershed when measured by the age threshold. If other DNR management strategies and mitigation are considered such as Riparian Management Zones, potential slope instability management, visual area management, adjacency of regeneration harvest, leave trees, etc., then on average, a watershed will have approximately half of the forested trust lands ownership in either a riparian or an upland area with specific objectives (see Table 4.15-21 for a summary and Appendix E for list of details on individual watersheds). The combined effect of DNR's forest management policies and procedures appears to provide protection to the resources that might be at potential risk to cumulative effects of timber harvesting in these watersheds. DNR's forest management policies and procedures will assist in the reduction of overall levels of cumulative effects in the future. In addition, DNR's policies and procedures should act in combination with Forest Practices Rules and the Northwest Forest Plan to reduce cumulative effects.

Table 4.15-20. Estimated Number of Watersheds From the "179 Watersheds" Having Less Than 50 Percent of Their Forested Trust Lands Area in Forest 25 Years or Older

Alternative	2004	2013	2031	2067
1	5	0	0	0
2	5	1	0	1
3	5	1	4	3
4	5	0	0	2
5	6	3	1	1
PA	5	3	1	0

PA = Preferred Alternative

Table 4.15-21. Land Class Area (expressed as a Percentage of the Total Area by State Trust Ownership group) in each HCP Planning Unit

State Trust Ownership Group	HCP Planning Unit	Uplands with General Objectives	Uplands with Specific Objectives	Riparian and Wetlands
Less than 22 percent of the watershed	Columbia	40%	28%	32%
	North Puget	22%	55%	23%
	OESF	0%	63%	37%
	South Coast	43%	20%	37%
	South Puget	42%	38%	20%
	Straits	50%	33%	17%
	Overall	34%	39%	27%
More than 22 percent of the watershed	Columbia	23%	44%	33%
	North Puget	22%	53%	25%
	OESF	0%	56%	44%
	South Coast	52%	14%	34%
	South Puget	2%	71%	27%
	Straits	53%	27%	20%
	Overall	22%	45%	32%
	Total	26%	43%	31%

Coupled with regulatory and federal land management provisions, all of the Alternatives, and their associated policies and procedures, mitigate significant adverse cumulative effects.

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